Service

Commercial Mobile Generator Sets

Models:

7ER

6EFR

ISO 9001
KOHLER GENERATORS
INTERNATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6035 1/00

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IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

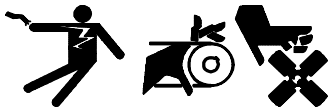
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Battery

WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove wristwatch, rings, and other jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner removed.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING

Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building or vehicle. Do not obstruct the exhaust outlet when parking your vehicle. The exhaust gases must discharge freely to prevent carbon monoxide from deflecting into the vehicle.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Installing the exhaust tail pipe. Carbon monoxide can cause severe nausea, fainting, or death. Install the exhaust system tail pipe to prevent the drawing of discharged exhaust gases into the vehicle interior through windows, doors, air conditioners, and other openings. Do not use flexible tail piping because it could crack and allow lethal exhaust fumes to enter the vehicle.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the vehicle's occupants, install a carbon monoxide detector. Consult the coach builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/Electrical Shock

⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING

Hazardous voltage.
Backfeed to the utility system can cause severe injury, death, or property damage.

Connect the generator set to the building's electrical system only through an approved device and after the building's main switch is opened.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove wristwatch, rings, and jewelry before servicing the equipment.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator.
(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/campground electrical system only through an approved device and after the building/campground main switch is opened. Backfeed connections can cause serious injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a transfer switch to prevent interconnection of the generator set power and other sources of power.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove rings, wristwatch, and jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

Heavy Equipment

⚠ WARNING

Unbalanced weight.
Improper lifting can cause severe injury or death and equipment damage.

Do not use lifting eyes.
Use slings under the skid to balance and lift the generator set.

Hot Parts

⚠ WARNING

Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Checking the coolant level. Hot coolant can cause severe injury or death. Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

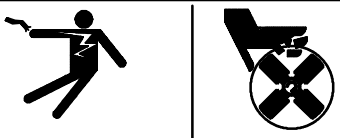
Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Combustible materials. Fire can cause severe injury or death. A hot exhaust system can ignite adjacent combustible materials. Do not locate electrical wiring, fuel lines, or combustible materials above the exhaust muffler. Exercise caution when parking your vehicle to prevent the exhaust system and hot exhaust gases from starting grass fires.

Combustible materials. Fire can cause severe injury or death. A hot generator set can ignite debris in the compartment. Keep the compartment and generator set clean and free of debris and combustible materials to minimize the possibility of fire. Do not block the fuel/oil drain opening in the generator set mounting tray. Cut a corresponding hole in the subfloor, if used, for the drain opening.

Moving Parts

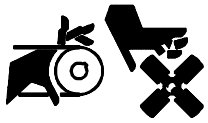
⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Tightening the hardware. Flying projectiles can cause severe injury or death. Loose hardware can cause the hardware or pulley to release from the generator set engine and can cause personal injury. Retorque all crankshaft and rotor hardware after servicing. Do not loosen the crankshaft hardware or rotor thrubolt when making adjustments or servicing the generator set. Rotate the crankshaft manually in a clockwise direction only. Turning the crankshaft bolt or rotor thrubolt counterclockwise can loosen the hardware.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Canadian installations only. For standby service connect the output of the generator set to a suitably rated transfer switch in accordance with Canadian Electrical Code, Part 1.

NOTICE

This generator set does not comply with United States Coast Guard (USCG) requirements and must not be used for marine applications. For marine installations use only generator sets specified for marine use. USCG Regulation 33CFR183 requires that a generator set must be ignition protected when used in a gasoline-fueled environment.

Notes

Introduction

This manual provides troubleshooting and repair instructions for 7ER/6EFR model generator sets, controllers, and accessories.

Refer to the engine service manuals (TP-6002 and TP-6008) for generator set engine service information.

This manual may be used for models not listed on the front cover.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably-trained maintenance personnel, familiar with generator set operation and service.

Service Assistance

Service Information

Please contact a local authorized distributor/dealer for sales, service, or other information about Kohler Generator Division products.

To locate a local authorized distributor/dealer inside the U.S.A. and Canada

- Look on the product or in the information included with the product
- Consult the Yellow Pages under the heading Generators— Electric
- Visit the Kohler Generator Division web site at www.kohlergenerators.com
- Call 1-800-544-2444

To locate a local authorized distributor/dealer outside the U.S.A. and Canada

- Look on the product or in the information included with the product
- Consult the telephone directory under the heading Generators—Electric
- Visit the Kohler Generator Division web site at www.kohlergenerators.com
- Contact the nearest regional office

Africa, Europe, Middle East
London Regional Office
Langley, Slough, England
Phone: (44) 1753-580-771
Fax: (44) 1753-580-036

Australia
Australia Regional Office
Queensland, Australia
Phone: (617) 3893-0061
Fax: (617) 3893-0072

China
China Regional Office
Shanghai, People's Republic of China
Phone: (86) 21-6482 1252
Fax: (86) 21-6482 1255

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80-2284270
(91) 80-2284279
Fax: (91) 80-2284286

Japan
Japan Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, U.S.A.
Phone: (941) 619-7568
Fax: (941) 701-7131

South East Asia
Singapore Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

Product Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Number _____

Serial Number _____

Generator Set Identification Numbers

Record the product identification numbers from the generator set nameplate(s).

Model Number _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

1.1 General

The 7ER and 6EFR units are powered by a two-cylinder, water-cooled, four-cycle gasoline engine.

Kohler Co. develops all Kohler mobile generator set ratings using accepted reference conditions of 25°C (77°F) and pressure of 98.9 kPa (29.2 in. Hg) dry barometer. ISO 3046 and ISO 8528-1 include reference conditions and output calculations. The nominal ratings are ±5%.

1.2 Engine

Generator Model	7ER	6EFR
Engine manufacturer	Kawasaki	
Engine model	FD501D	
Number of cylinders	2	
Cylinder block material	Aluminum	
Cylinder head material	Aluminum	
Piston rings	2 compression/1 oil	
Connecting rod material	Steel	
Governor	Gear driven centrifugal	
Bore x stroke, mm (in.)	67 (2.64) x 62 (2.44)	
Displacement, L (CID)	437 (26.7)	
Compression ratio	9.3:1	
Horsepower, 60/50 Hz	16	13.8
RPM, 60/50 Hz	3600	3000
Lubrication system	Pressure; mechanical	
Lube oil capacity (w/filter), L (U.S. qts)	1.36 (1.44)	
Low oil pressure shutdown, kPa (psi)	96.5 (14)	
Oil recommendation (API)	SC,SD,SE,SF,SG, or SH	
Battery voltage	12 volt (standard)	
Battery recommendation, min.	260 CCA	
Battery charging	15 amps	
Starter motor	Bendix automotive type	

1.3 Fuel

Fuel System	7ER	6EFR
Fuel recommendation	Unleaded 87 octane	
Fuel pump	Electric	
Fuel pump operating, kPa (psi)	13.8-24.1 (2.0-3.5)	
Fuel pump inlet	1/8 NPTF	

1.4 Cooling

Recommended coolant	50% ethylene glycol; 50% clean, softened water
Coolant capacity (approx.), L (U.S. qts.)	2.0 (2.1)
Thermostat	71°C (160°F)
Pressure cap rating	97 kPa (14 psi)
High temperature shutdown	111°C (232°F)
High exhaust temperature shutdown	102°C (215°F)

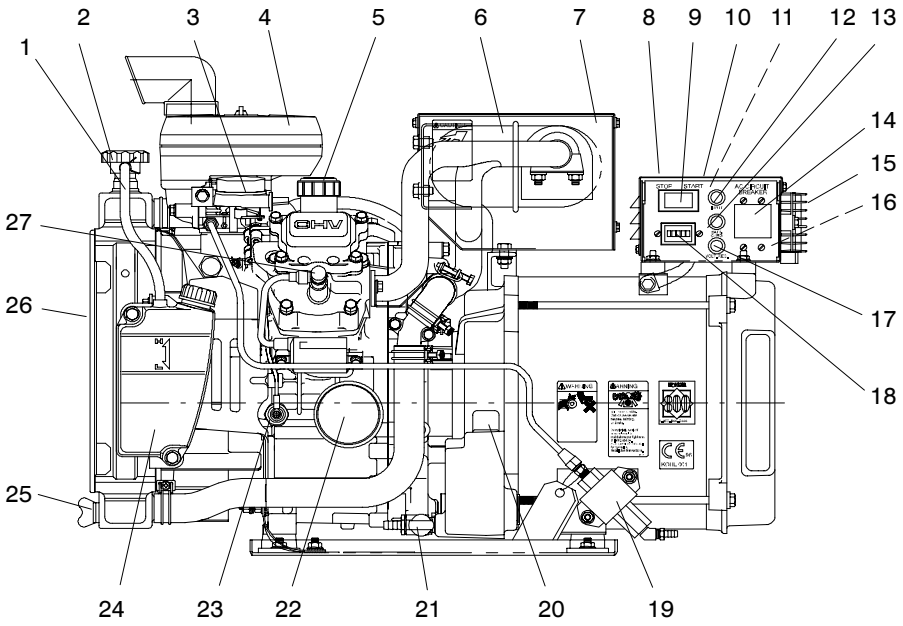
1.5 Generator

Hot exciter field voltage/current readings at rated voltage	
No load (63 Hz) (volts/amps)	10.1/4.4
Full load (60 Hz) (volts/amps)	50.5/8.5
Cold main field (rotor) resistance (ohms)	3.7
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)	
1-2, 3-4, 33-44 (volts)	145
55-66 (volts)	190
B1-B2 (volts)	14
Cold stator resistance	
1-2, 3-4, 33-44 (ohms)	0.32
55-66 (ohms)	1.70
B1-B2 (ohms)	0.05

1.6 Torque

Component	Torque Nm (in. lbs.)
Rotor bolt	23.1 (204)
Generator overbolts	13.6 (120)
Mounting plate to end bracket bolts	6.8 (60)
Lift eyebolts	19.0 (168)
Generator adapter to engine bolts	14.9 (132)
Engine oil drain boss (inside generator adapter)	47.5 (420)
Generator adapter to exhaust manifold	13.6 (120)
High exhaust temp. switch (HET)	13.6 (120)
Spark plugs	12-17 (106-150)

1.7 Service View

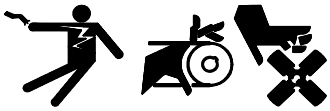


1. Overflow tube
2. Pressure cap
3. Choke heater
4. Air intake silencer
5. Oil filler cap
6. Muffler
7. Exhaust bracket
8. Controller
9. Start/Stop switch
10. Nameplate (top)
11. AC load lead connector (nonservice side)
12. Input fuse
13. Battery charging fuse
14. AC circuit breaker
15. Voltage regulator
16. Remote start connector (nonservice side)
17. Voltage regulator fuse
18. Hourmeter
19. Fuel feed pump
20. Oil check
21. Oil drain valve
22. Oil filter
23. Low oil pressure switch
24. Coolant overflow bottle (daily coolant check/fill location)
25. Coolant drain
26. Radiator
27. Spark plug (also one on nonservice side)

Figure 1-1 Service View

2.1 General

⚠ WARNING

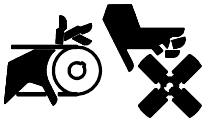


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Note: See the generator set operation manual for the service schedule and other service not included in this manual.

2.2 Lubrication System

Use oil that meets the American Petroleum Institute (API) classification of SC, SD, SE, SF, SG, SH, or SJ. Using unsuitable oil or neglecting an oil change may result in engine damage that is not covered by the engine warranty. Figure 2-1 shows the recommended Society of Automotive Engineers (SAE) viscosity designation for given operating temperature ranges.

Do not mix different oil brands. Incompatibility could cause a breakdown of lubricating ingredients and reduce engine protection.

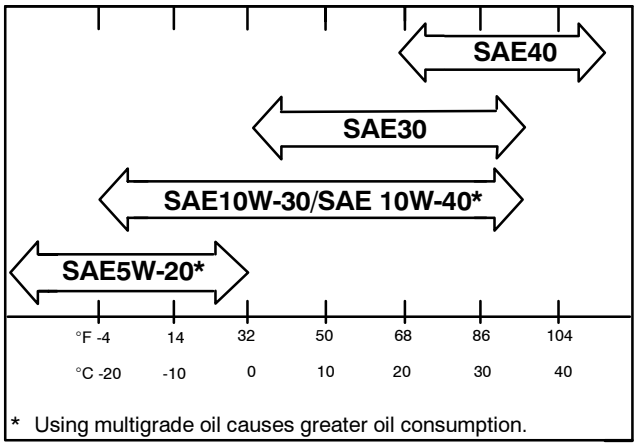

SAE40
SAE30
SAE10W-30/SAE 10W-40*
SAE5W-20*
°F -4 14 32 50 68 86 104
°C -20 -10 0 10 20 30 40
* Using multigrade oil causes greater oil consumption.

Figure 2-1 Recommended SAE Viscosity Grades

Notes

3.1 Air Cleaner

Check the air cleaner element for accumulated oil or dirt that could clog the element and cause poor performance.

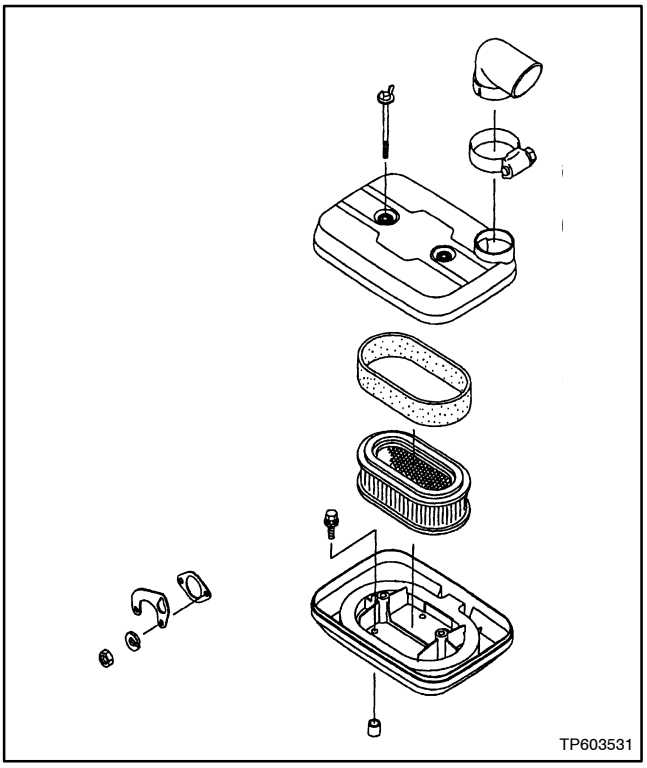
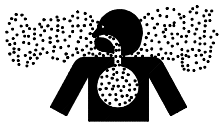


Figure 3-1 Air Intake Assembly

3.2 Exhaust Inspection

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the vehicle's occupants, install a carbon monoxide detector. Consult the coach builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

Exhaust System. Check for exhaust leaks and blockages. Check the muffler and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components for cracks and corrosion (exhaust manifold, exhaust line, exhaust clamps, and muffler).

- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace the exhaust clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Check the exhaust gas color. If the exhaust is blue or black, contact your local distributor/dealer.
- Visually inspect for exhaust leaks. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector is (1) in the vehicle, (2) functional, and (3) energized whenever the generator set operates.

Notes

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

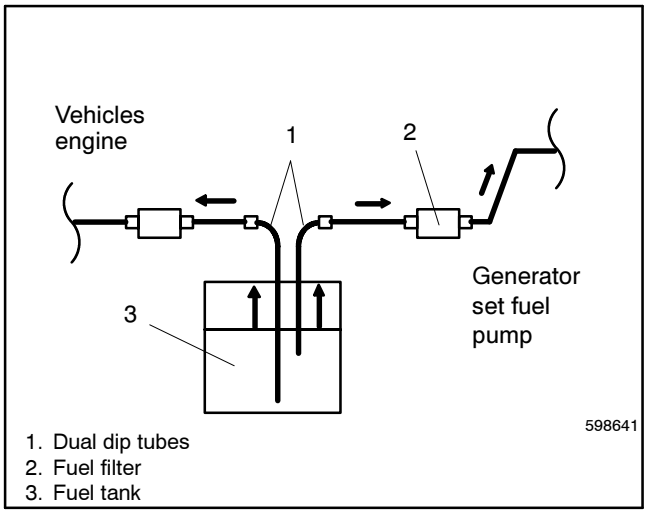
Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

4.1 General

In most installations, both the generator set and the vehicles engine operate from a common fuel tank with a dual dip tube arrangement. The generator set's dip tube may be shorter than the vehicles engine's dip tube. With this arrangement, fuel may not be available to the generator set when the fuel supply is low. See Figure 4-1 for fuel system schematic.



1. Dual dip tubes
2. Fuel filter
3. Fuel tank

Figure 4-1 Fuel System Schematic, Typical

4.2 Fuel Pump

Electric fuel pumps draw fuel from the fuel tank, through a filter, and supply clean fuel at the proper pressure and quantity to the generator set engine carburetor.

Fuel Pump Test Procedure

1. Connect the inlet side of the pump to a fuel source.
2. Disconnect the outlet hose from the fuel filter and place the end in a container to catch the fuel.
3. Disconnect the P9 connector.
4. Connect the positive (70) terminal of the fuel pump to the positive (+) terminal of a 12-volt battery.
5. Connect the negative (N) terminal of the fuel pump to the negative (-) terminal of the battery. The pump should operate and fuel should discharge

from the pump outlet. If the pump does not operate, replace the pump.

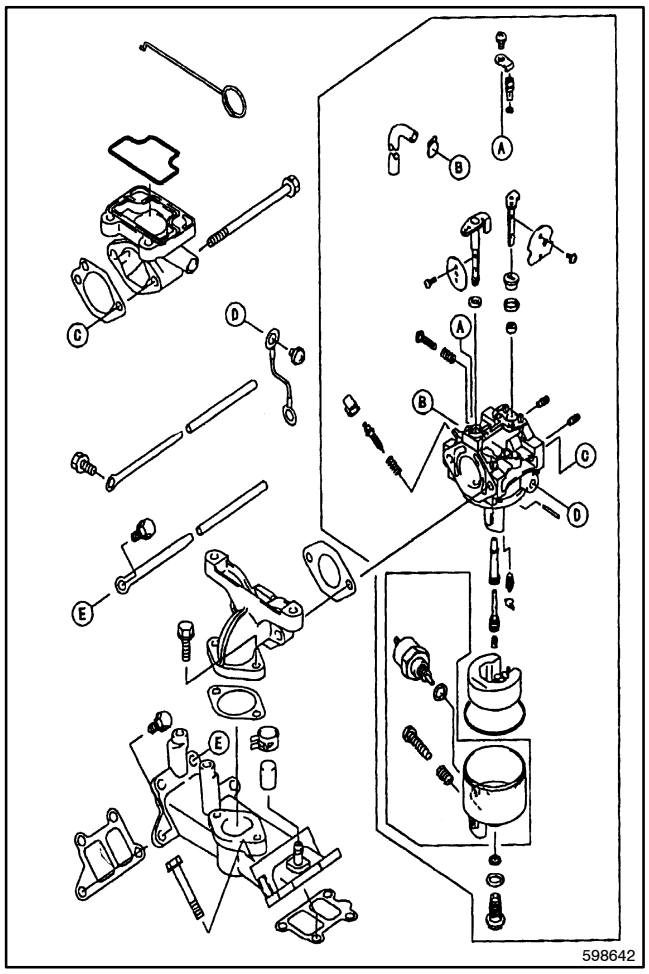


Figure 4-2 Fuel System Exploded View

4.3 Carburetor Troubleshooting

This section is for fuel-related problems only. Use for basic carburetor troubleshooting.

Note: When troubleshooting the fuel system, it is important to have an adequate fuel supply.

A lean or rich fuel condition can reduce power output and cause poor acceleration.

Symptoms of a Lean Condition

- Hard starting
- Stalling
- Hunting

Symptoms of a Rich Condition

- Hard starting
- Stalling
- Percolation
- Flooding
- Leaking carburetor

4.3.1 Hard Starting

A flooded engine, improperly adjusted or inoperative choke, dirty carburetor (lean condition), or improper idle fuel mixture can cause hard starting.

4.3.2 Stalling

Improper idle air/fuel mixture or a dirty carburetor can cause stalling. Clogged idle air bleeds, idle air passages, or an idle discharge port can cause stalling because of a lean condition. Clean or adjust the carburetor.

4.3.3 Flooding

Flooding occurs from a float level set too high, improperly adjusted fuel pressure, improperly installed fuel pump, a sticking choke plate or float, or a fuel inlet needle held off its seat either by improper seating or dirt particles. A punctured or leaking float admitting fuel becomes gas-logged causing a heavy float, high fuel level, and flooding.

If flooding occurs, disassemble the carburetor, observe the operation and condition of components, and repair or replace components as necessary.

4.3.4 Hunting

A low fuel level because of an improperly adjusted float, a clogged main jet, restricted main jet passages, or an improperly sized main jet for the application can cause hunting. Clean, adjust, or replace inoperative components.

An incorrect throttle linkage adjustment, a binding throttle linkage, a sticking throttle shaft, or a loose throttle shaft in the throttle body or bore can cause inconsistent idle speed.

4.3.5 Leaking Carburetor

Loose fuel connections, a cracked carburetor body, a sticking fuel inlet needle, or an inoperative float can cause a leaking carburetor. Adjust, repair, or replace the affected components.

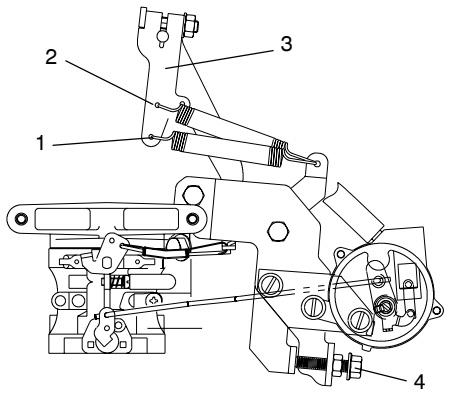
4.4 Governor 60 Hz to 50 Hz Conversion

Governors are adjusted at the factory and further adjustments should not be necessary.

Note: Never tamper with the governor settings to increase the generator output. Overspeeding can cause equipment parts to exceed design limitations, resulting in component failure.

Governor 60 Hz to 50 Hz Conversion Procedure

1. Change the spring to the 50 Hz position. See Figure 4-3.
2. Adjust the generator frequency using a frequency meter. Set the no load speed at 52.5 Hz for 50 Hz operation or 63 Hz for 60 Hz operation.
3. Replace the governor speed adjusting bolt. The 50 Hz bolt is X-6284-7 and is 65 mm (2.56 in.) long. The 60 Hz bolt is M933-5050-60 and is 50 mm (1.97 in.) long.
4. Adjust the voltage regulator volt/Hz rolloff point. Refer to Section 7.2.2.



1. 60 Hz governor spring position
2. 50 Hz governor spring position
3. Governor arm
4. Governor speed adjusting bolt (X-6284-7 for 50 Hz, M933-5050-60 for 60 Hz)

Figure 4-3 Governor 60 Hz to 50 Hz Conversion

Notes

5.1 General

⚠ WARNING

Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

Checking the coolant level. Hot coolant can cause severe injury or death. Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

5.2 Check and Fill Coolant

Keep the coolant recovery tank approximately 1/4 full. Before filling the cooling system, close all petcocks and tighten all hose clamps. Use a solution of 50% ethylene glycol and 50% clean, softened water to inhibit rust/corrosion and prevent freezing. Add additional coolant mixture, as necessary, to the coolant recovery tank. Periodically check the coolant level on closed systems by removing the pressure cap. Do not rely solely on the level in the coolant recovery tank. Add fresh coolant until the level is just below the overflow tube opening.

Do not add coolant to a hot engine. Adding coolant to a hot engine can cause the cylinder block or cylinder head to crack. Wait until the engine has cooled.

Note: Coolant solution. A coolant solution of 50% ethylene glycol provides freezing protection to −37°C (−34°F) and overheating protection to 129°C (265°F). A coolant solution with less than 50% ethylene glycol may not provide adequate freezing and overheating protection. A coolant solution with more than 50% ethylene glycol can cause engine or component damage. Do not use alcohol or methanol antifreeze or mix them with the specified coolant. Consult the engine manufacturer's operation manual for engine coolant specifications.

5.3 Flush and Clean Cooling System

For optimum protection, drain, flush, and refill the cooling system at the interval listed in the operation manual's service schedule.

Pay special attention to the coolant level. Check the coolant level as described earlier.

Flush and Clean Procedure

1. Open the coolant drain. See Section 1.7, Service View, for location.
2. Remove the pressure cap to simplify draining.
3. Drain, clean, and flush the coolant recovery tank.
4. Flush the system with clean water.
5. Close the coolant drain.
6. Fill the cooling system with the recommended coolant.
7. Reinstall the pressure cap.

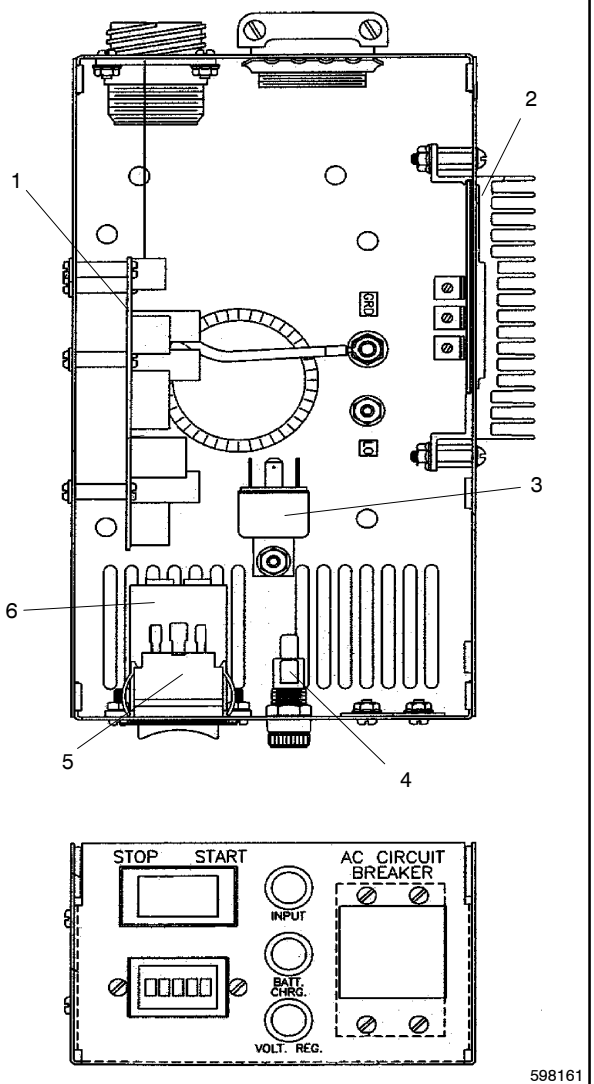
5.4 Generator Storage

Follow the procedure below when storing your generator set for 3 months or more.

1. Add fuel stabilizer to the fuel tank of gasoline-powered generator sets. Follow the fuel stabilizer manufacturer's recommendation.
2. Start and run the generator set until it reaches operating temperature, about 30 minutes.
3. Stop the generator set.
4. Change the oil and oil filter. See the operation manual.
5. Stop the generator set.
6. Check the coolant level of the radiator and the coolant recovery tank. Fill the cooling system using an antifreeze with the lowest temperature rating.
7. Clean the exterior of the generator set and spread a light film of oil or silicon spray over any exposed surfaces which may be subject to rust or corrosion.
8. Remove the spark plugs.
9. Pour one tablespoon of engine oil into each spark plug hole.
10. Toggle the generator set start/stop switch to crank the engine two or three revolutions to lubricate the cylinders.
11. Reinstall the spark plugs and torque them to specifications.
12. Disconnect and remove the battery. Place the battery in a dry location for the storage period. Recharge the battery once a month to maintain a full charge.
13. Cover the entire unit with a breathable dust cover.

6.1 Sequence of Operation

This section describes the controller sequence of operation during the generator start, run, stop, and fault shutdown modes and describes the relay testing procedures. Use this section as a starting point for controller fault identification. Use the LEDs on the controller circuit board to assist in the troubleshooting process. An illuminated LED indicates that the respective relay is receiving power; the LED does not indicate whether that relay is energized or working properly.



1. Controller circuit board
2. PBIIIE voltage regulator
3. K20 relay
4. Fuses
5. Start/stop switch
6. Hourmeter

Figure 6-1 Controller

6.1.1 Start

Close the start/stop switch between N and 47 (local or remote).

The K2 relay energizes and LED2 is illuminated. The normally open K2 contacts close to energize the K3 relay (LED3 lights), fuel pump (FP), choke heater (CHTR), antidiesel solenoid (ADS), ignition (IGN), hourmeter (HR), and the main field (FP and FN).

Flashing of the main field occurs when the K2 contacts close.

The normally open K3 contacts close to energize the K20 relay. The normally open K20 contacts close, energizing the starter relay (SR). The SR normally open contacts close to energize the starter motor (SM).

Note: The normally closed LOP contacts open when the engine builds oil pressure. This may take a few seconds after engine cranking is initiated.

6.1.2 Run

The bridged rectifier (BR1) receives AC voltage (12–15-volts) through the B1 and B2 windings of the stator.

The K1 relay energizes (LED1 lights).

The normally open K1 contacts close to maintain voltage to the K2 relay, allowing the function of the fuel pump (FP), choke heater (CHTR), antidiesel solenoid (ADS), ignition (IGN), hourmeter (HR), and the remote panel gauges.

The normally closed K1 contacts open, ending the flashing by preventing battery voltage to the main field (+) and (–).

The K6 relay energizes. The normally open K6 contacts close, latching itself on. The normally closed K6 contacts open, preventing inadvertent starter engagement by disabling the K3 relay.

The K3 relay is deenergized (LED3 off). The K3 contacts open, deenergizing the K20 relay. The K20 contacts open, deenergizing the starter relay and starter motor.

At the same time the K1 relay is energized, the time delay for the K5 relay starts. After 5–10 seconds, the K5 relay is energized (LED 5 lights).

The normally open K5 contacts close to permit the function of the engine safety shutdown switches.

6.1.3 Stop

Close the start/stop switch between N and 43 (local or remote).

The K4 relay energizes (LED4 lights).

The normally closed K4 contacts open, disabling the fuel pump (FP), choke heater (CHTR), antidiesel solenoid (ADS), and ignition (IGN).

The normally open K4 contacts close, latching the circuit to the K4 relay until the generator set comes to a complete stop.

6.2 Engine Safety Shutdown Switches

6.2.1 Low Oil Pressure (LOP) Shutdown

When low oil pressure occurs, the LOP shutdown switch contacts close energizing the K4 relay (LED4 lights). The generator shuts down, as described in Section 6.1.3.

Note: During cranking, the low oil pressure shutdown switch deactivates until the K5 relay energizes. This delay allows the engine to reach normal operating oil pressure.

6.2.2 Loss of Coolant Switch (LCS) Shutdown

When the coolant level is low, the LCS contacts close, energizing the K4 relay (LED4 lights). The generator shuts down, as described in Section 6.1.3.

6.2.3 High Engine Temperature Switch (HET) Shutdown

When the engine temperature exceeds 111°C (232°F), the HET contacts close, energizing the K4 relay (LED4 lights). The generator shuts down, as described in Section 6.1.3.

6.2.4 Controller Circuit Board

The controller circuit board has light emitting diodes (LEDs) that indicate the presence of relay coil power. When any of the relays K1–K5 receives power, the corresponding LED lights.

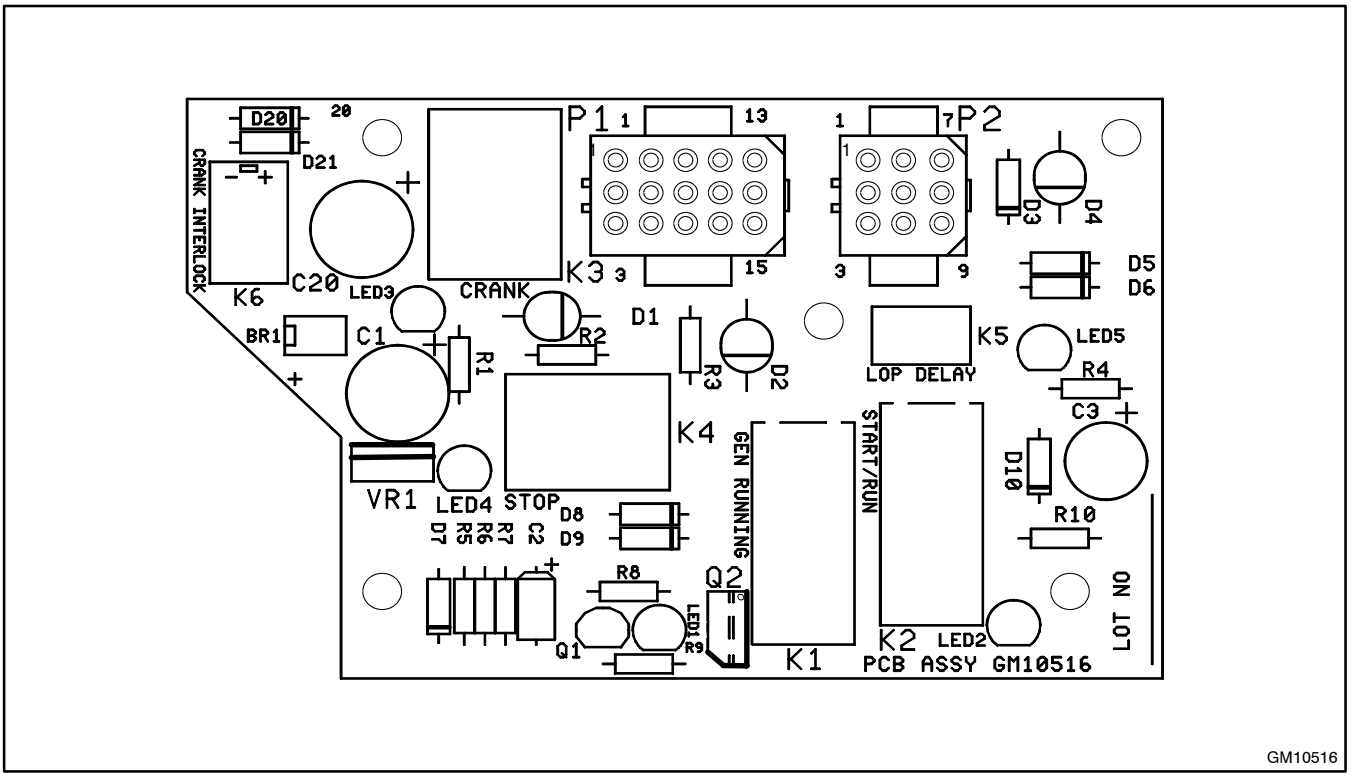


Figure 6-2 GM10516 Controller Circuit Board

6.2.5 Troubleshooting

Use the following flow chart as an aid in troubleshooting the main circuit board and the entire generator set. If the prescribed remedy does not correct the problem, the circuit board may have to be replaced. Use this chart for component testing only. Always check the continuity of the wires between components. Always disconnect external components (remote start/stop switches, engine gauge panel, dry relay contact kits, etc.) before performing troubleshooting procedures.

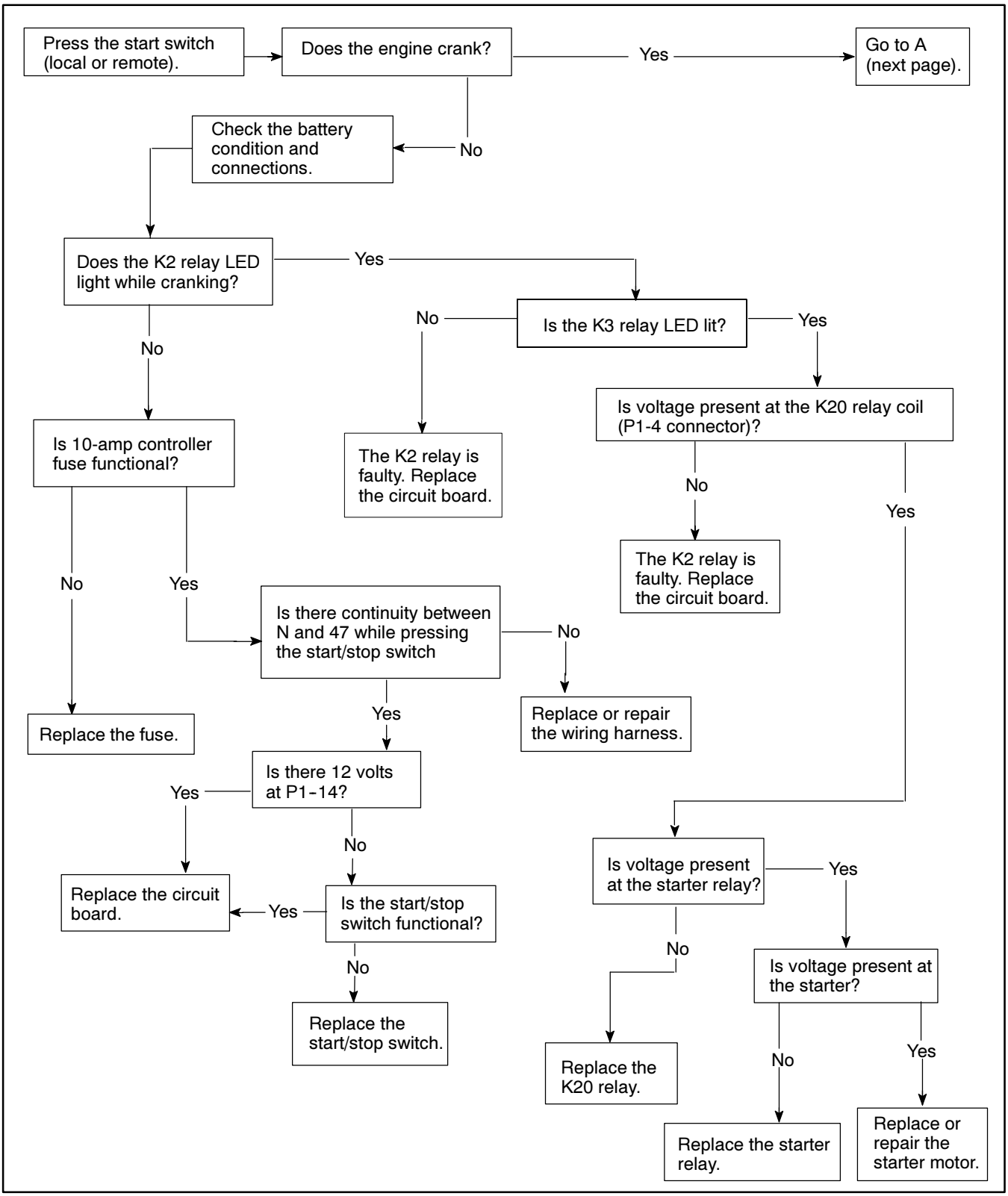


Figure 6-3 Troubleshooting Relay Controller Circuit Board (1 of 4)

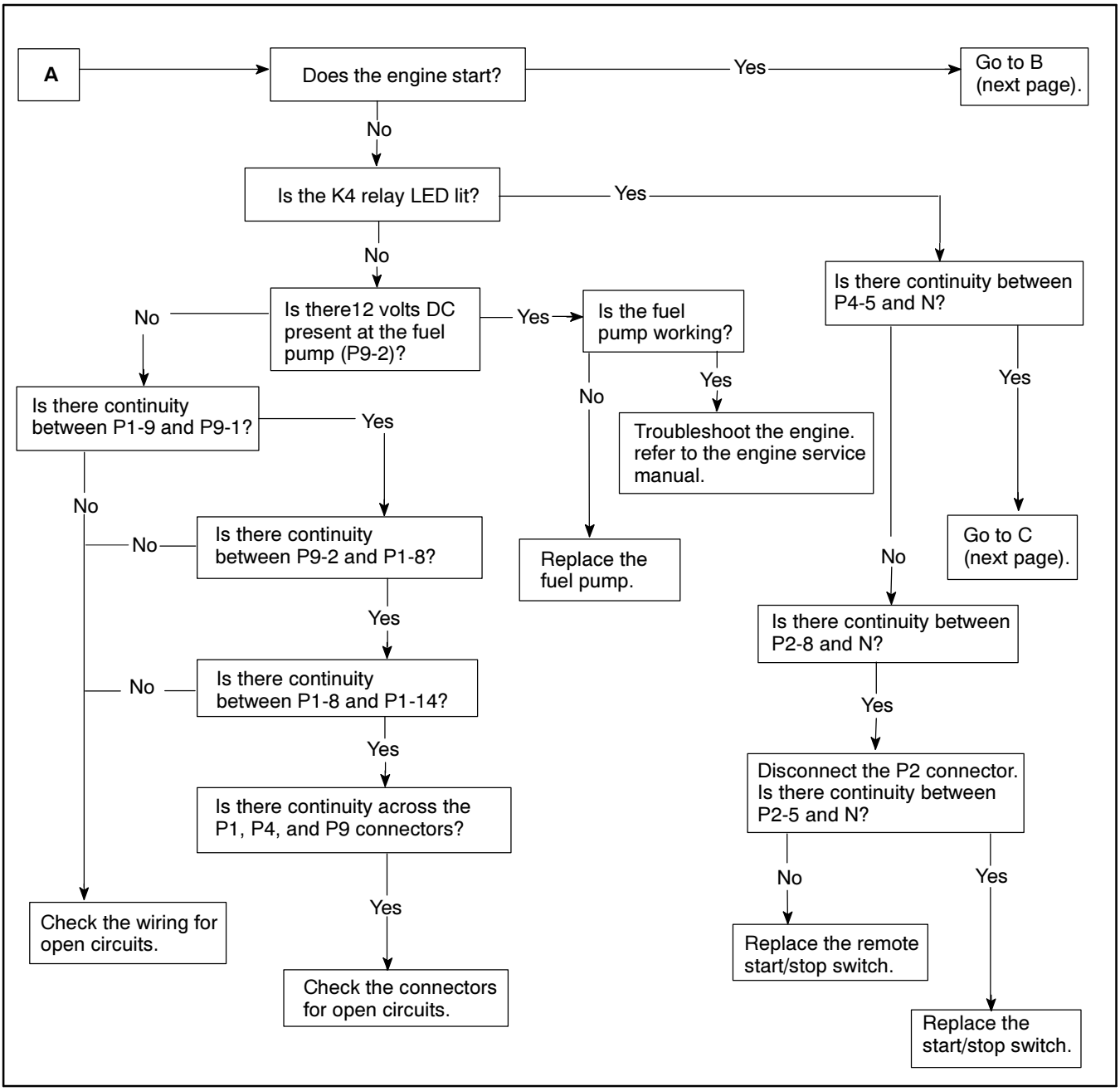


Figure 6-4 Troubleshooting Relay Controller Circuit Board (2 of 4)

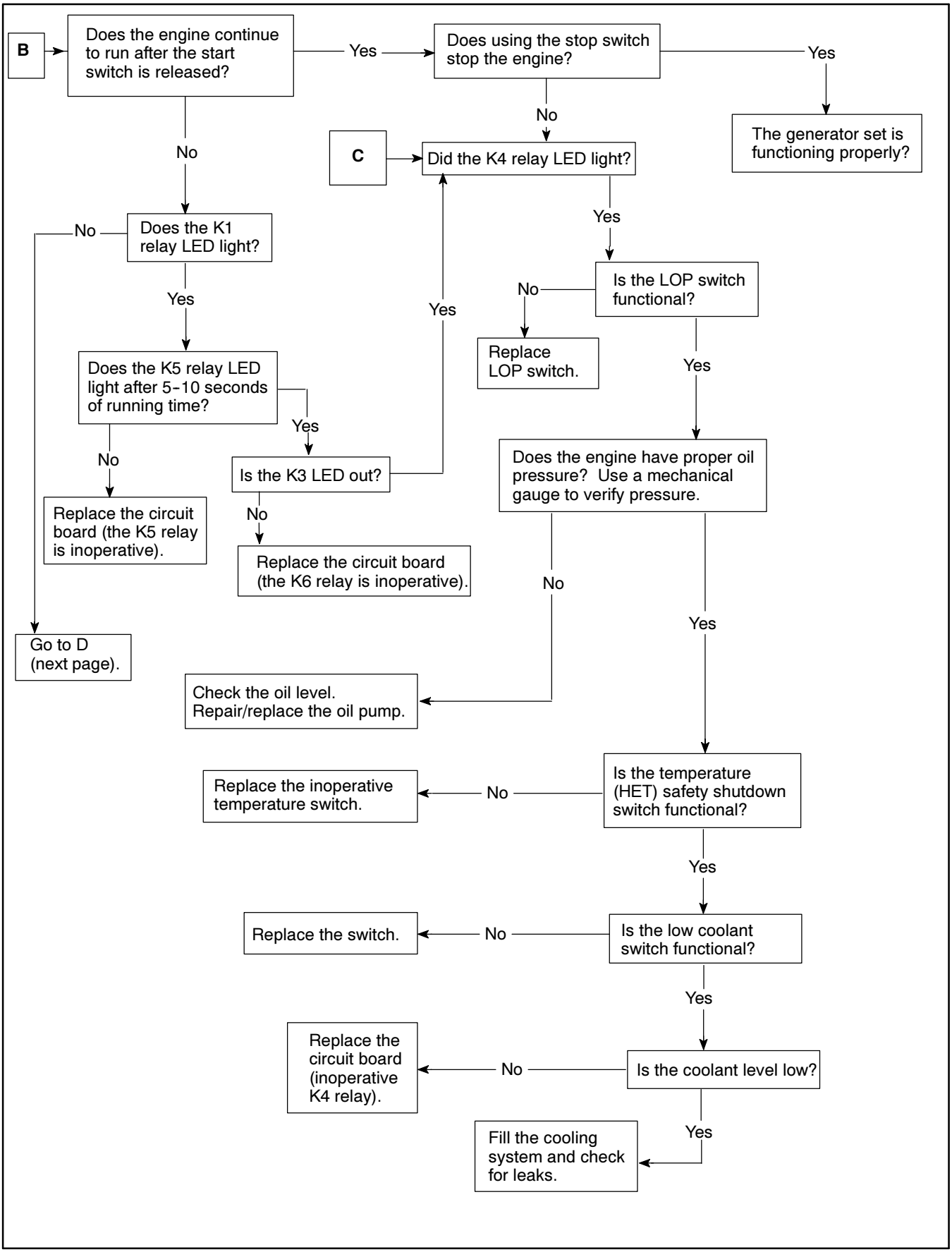


Figure 6-5 Troubleshooting Relay Controller Circuit Board (3 of 4)

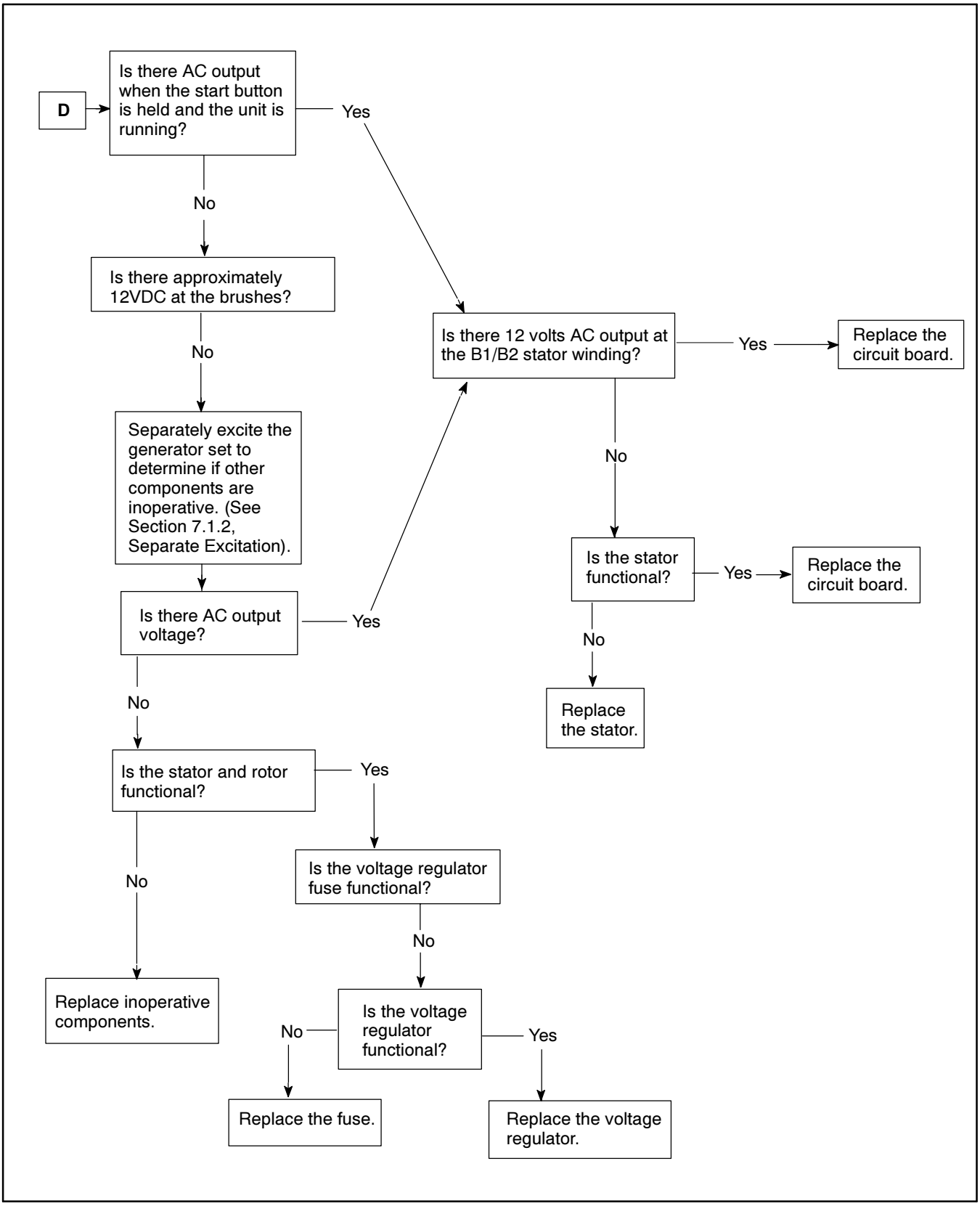


Figure 6-6 Troubleshooting Relay Controller Circuit Board (4 of 4)

7.1 General

Before beginning the following troubleshooting procedures, read all the safety precautions at the beginning of this manual. The following tests include additional safety precautions; OBSERVE THESE PRECAUTIONS!

⚠ WARNING

Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator.
(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove wristwatch, rings, and jewelry before servicing the equipment.

7.1.1 General Troubleshooting

To determine the cause of no- or low-AC output , refer to the following steps and the troubleshooting flow chart (Figure 7-1). Verify the operation of the alternator components before replacing the controller board or voltage regulator.

1. Check the condition of the voltage regulator's 10-amp fuse.
2. If the fuse is functional, separately excite the generator. (See Section 7.1.2.) The separate excitation test duplicates the role of the voltage regulator by providing excitation current to the rotor.

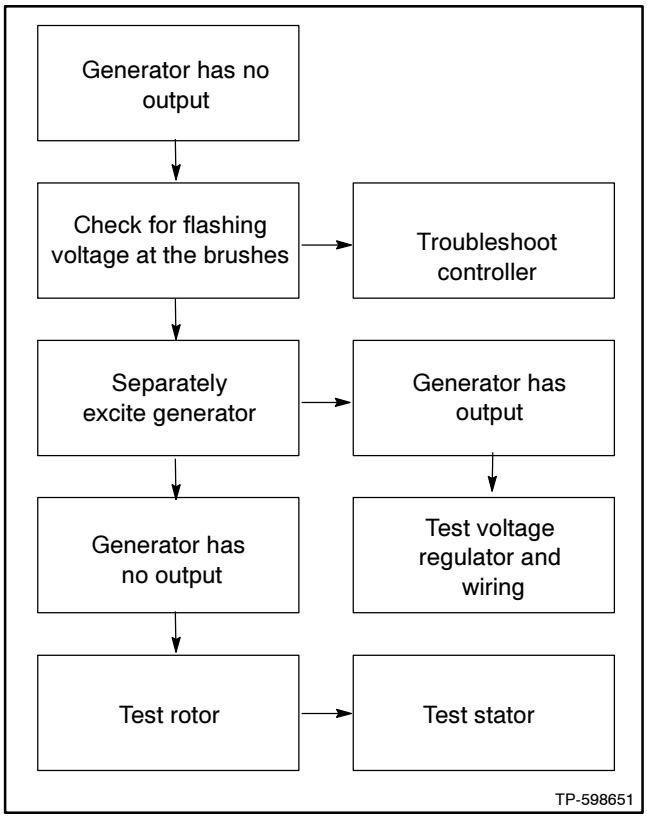


Figure 7-1 General Troubleshooting

7.1.2 Separate Excitation

By separately exciting the generator to determine the presence of a faulty voltage regulator, it is possible to determine if a running fault exists in the rotor and/or stator. A generator component that appears functional while static (stationary) may exhibit a running open or short circuit while dynamic (moving). Centrifugal forces acting on the windings during rotation or insulation breakdown as temperatures increase can cause short circuits.

Note: It is not necessary to separately excite the generator if there is AC output with flashing voltage.

Separate Excitation Procedure

1. Disconnect all of the leads from the voltage regulator.

2. Disconnect the P10 (F1, F2) connector.

3. Connect a separate excitation circuit as shown in Figure 7-2. Connect an ammeter and a 10-amp fuse in series with F1. Note and record the ammeter reading.

4. The approximate ammeter reading should equal battery voltage divided by the specified rotor resistance (cold). See Section 1, Specifications, for the correct values.

   Example:

   $$\frac{\text{12 Volts (Battery Voltage)}}{\text{3.7 Ohms Rotor Resistance}} = \text{0.6-amp Ammeter reading}$$

5. Start the engine and check that the ammeter remains stable. An increasing meter reading indicates a shorted rotor. A decreasing meter reading to zero, or unstable reading, suggests a running open in the rotor. If the ammeter is stable, continue with step 6.

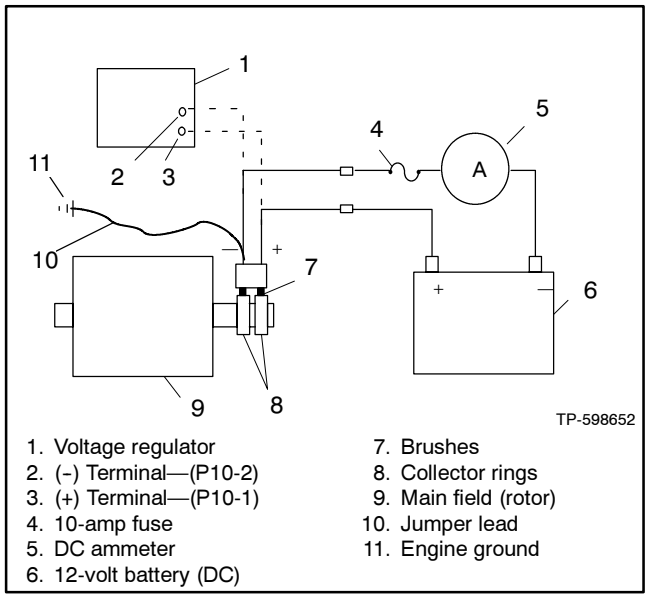
6. With a jumper wire, ground the negative (-) lead from the rotor to the engine block. An increased current reading or a fluctuating reading indicates a grounded rotor winding. Replace the rotor if the ammeter reading fluctuates. If the ammeter is stable, continue with step 7.

7. Remove the jumper wire and reverse the positive (+) and negative (-) leads on the rotor. Repeat step 5. If the ammeter is stable, ground the negative (-) lead at its new location on the rotor to the engine block. Replace the rotor if the ammeter reading fluctuates.

8. Check for AC output across the stator leads and compare the measured output to the values in Section 1, Specifications. If the output varies considerably from those listed, a faulty stator, rotor, rectifier module, or armature is likely.

If there is no generator output during normal operation, but output is available when the generator set is separately excited, the voltage regulator may be inoperative.

Note: See Section 1, Specifications, for the stator output voltages (with separately excited generator). These specifications are based on a battery voltage of 12 volts. Should the battery voltage vary, the resulting stator output values will also vary.

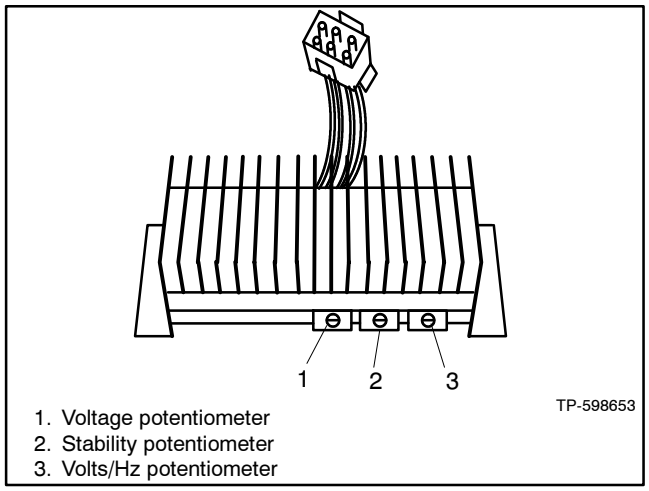


1. Voltage regulator
2. (-) Terminal—(P10-2)
3. (+) Terminal—(P10-1)
4. 10-amp fuse
5. DC ammeter
6. 12-volt battery (DC)
7. Brushes
8. Collector rings
9. Main field (rotor)
10. Jumper lead
11. Engine ground

Figure 7-2 Separate Excitation Connections

7.2 PowerBoost IIIE Voltage Regulators

The generator set is equipped with a PowerBoost™ IIIE voltage regulator. See Figure 7-3.



1. Voltage potentiometer
2. Stability potentiometer
3. Volts/Hz potentiometer

Figure 7-3 PowerBoost™ IIIE Voltage Regulator

The voltage regulator monitors the output voltage of the generator set.

The 10-amp regulator fuse protects the alternator stator windings (power supply) 55-33 from excessive current draw because of an inoperative voltage regulator or a downstream short. If the regulator's 10-amp fuse blows, the generator set will shut down. Verify that the regulator fuse is functional before proceeding with the test.

7.2.1 Voltage Regulator Test

Perform the following test to check the regulator output. Use the following components to test the voltage regulator:

- Variable transformer, 0–140 volts, 0.5-amp minimum
- Plug, 120 volt AC
- Lamp, 120 volts, 100 watts
- AC voltmeter
- Insulated copper wire, #14 AWG , minimum

Regulator Test Procedure

1. Connect the components as shown in Figure 7-4.

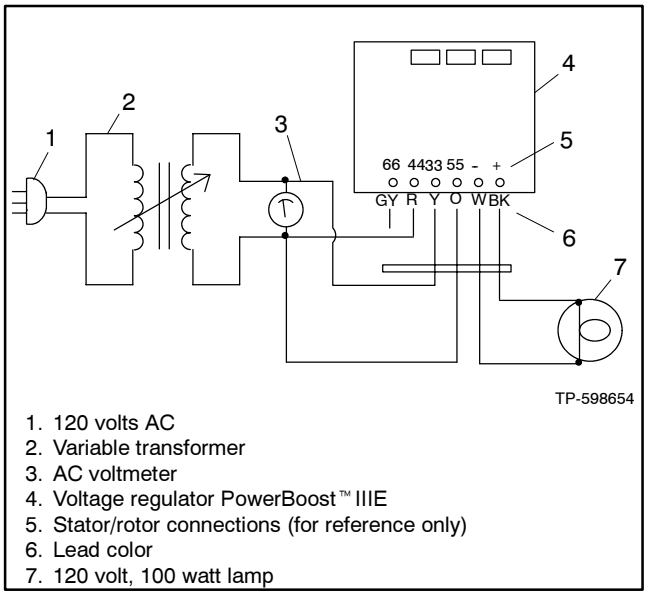
2. Turn the variable transformer setting to zero. Plug in the variable transformer.

3. Turn the variable transformer on. Slowly increase the variable transformer voltage to 100 volts. The test lamp should light. If the lamp does not light, turn the voltage adjustment potentiometer (pot) clockwise. If the lamp still does not light, the voltage regulator is inoperative. Replace the voltage regulator. An inoperative voltage regulator causes a generator no- or low-output condition.

4. Slowly increase the voltage to 120 volts. The lamp should go out and stay out as the voltage increases. If the lamp remains lit, turn the voltage adjustment pot counterclockwise. If the lamp still remains lit, replace the voltage regulator. A voltage regulator which tests bad causes a generator high voltage output condition.

5. Turn the variable transformer to zero and unplug the AC cord.

   Note: For applications requiring fine voltage adjustment, connect a remote rheostat to voltage regulator terminal 66.



1. 120 volts AC
2. Variable transformer
3. AC voltmeter
4. Voltage regulator PowerBoost™ IIIE
5. Stator/rotor connections (for reference only)
6. Lead color
7. 120 volt, 100 watt lamp

Figure 7-4 PowerBoost™ IIIE Voltage Regulator Test

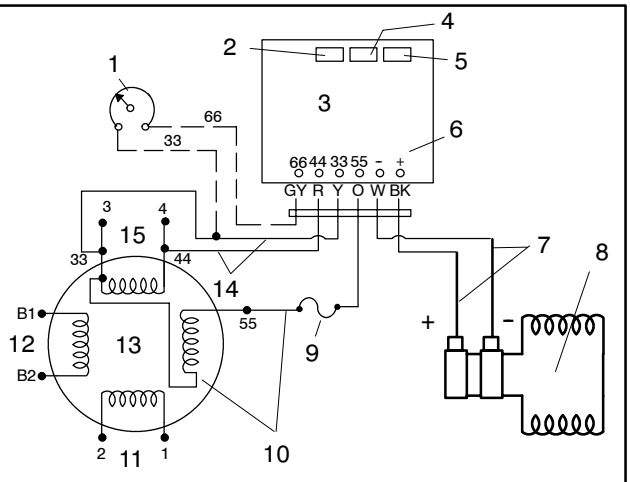
7.2.2 Voltage Regulator Adjustment

The factory sets the voltage regulator and under normal circumstances the regulator requires no further adjustment. However, if the voltage regulator has been replaced or tampered with, or if voltage/frequency reconnection has been done, readjust the voltage regulator according to the following procedure. See Figure 7-5. The following paragraphs describe the voltage regulator components.

Voltage Adjustment Pot adjusts the generator output within the range of 100–130 volts.

Stabilizer Pot fine-tunes regulator circuitry to minimize AC voltage fluctuation.

Volts/Hz Pot feature allows the voltage to drop if the load imposed on the generator causes the engine speed to fall below a predetermined rpm or frequency. This reduction of voltage results in a decrease of starting kW (load) allowing the governor to recover the engine speed.



1. Optional remote rheostat
2. Voltage adjustment pot
3. PowerBoost™ IIIE voltage regulator
4. Stabilizer pot
5. Volts/Hz pot
6. Stator/rotor connections (for reference only)
7. DC output
8. Rotor
9. 10-amp fuse
10. AC power input (aux.)
11. Main (2 and 1)
12. Control
13. Stator
14. Sensing
15. Main (3 and 4)

Figure 7-5 PowerBoost™ IIIE Voltage Regulator

Voltage Regulator Adjustment Procedure

1. Stop the generator set.
2. Turn the remote rheostat, if equipped, to the midpoint. Turn the voltage and stabilizer pots fully counterclockwise. Connect the voltmeter to the AC circuit or an electrical outlet.
3. Start the generator set.
4. Adjust the generator frequency using a frequency meter. Set the no load speed at 52.5 Hz for 50 Hz operation or 63 Hz for 60 Hz operation.
5. Rotate the voltage adjustment pot clockwise to increase the voltage or counterclockwise to decrease the voltage to achieve the desired output voltage.
6. Connect a 120-volt light bulb to the AC plug on the generator set.
7. Rotate the stability pot clockwise until the light bulb flickers minimally.
8. Readjust the voltage adjustment pot to achieve the desired output voltage.
9. Disconnect the 120-volt light bulb.
10. Turn the volts/Hz pot completely clockwise to decrease the Hz rolloff point. See Figure 7-6.
11. Set engine speed to 47.5 Hz for 50 Hz generator sets and 57.5 Hz for 60 Hz generator sets for the desired cut-in frequency.
12. Slowly turn the volts/Hz pot counterclockwise until the frequency matches that of the engine frequency (47.5 or 57.5 Hz) or until the voltage just begins to drop.
13. Reset the engine speed to the normal frequency (50 Hz or 60 Hz).
14. Recheck the AC voltage output and stability as described in steps 5–7.
15. Stop the generator set.

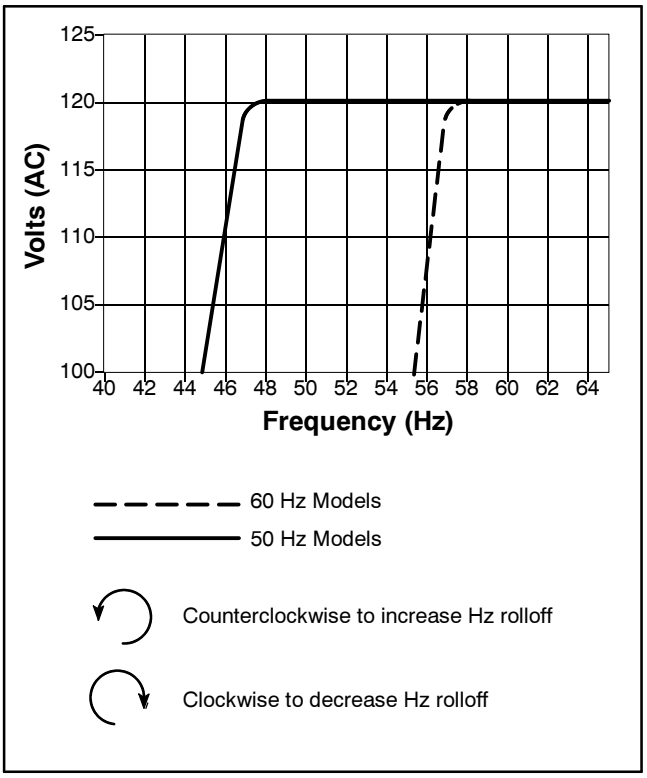


Figure 7-6 Volts/Hz Rolloff Chart

7.3 Rotor

The 2-pole rotor creates the magnetic field needed to sustain alternating current in the stator windings. Before testing, inspect the rotor for visible damage to pole shoes, insulation, exposed coil windings, and collector ring surfaces. Check the rotor bearing for noisy operation, excessive wear, radial or axial movement, and/or heat discoloration. Replace or repair as necessary.

Collector rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly machined appearance. Wipe the collector rings with a dry, lint-free cloth. Use a commutator stone to remove the groves on the collector rings. Do not use emery or carborundum paper or cloth. Remove all carbon dust from the generator. Remove the black or pitted surface of the collector rings using a lathe.

Check the rotor for continuity and resistance. Lift the brushes and measure the rotor resistance between the two collector rings. See Section 1.5.

Note: When checking rotor resistance with the rotor installed, brushes must not be in contact with rotor collector rings. Use a brush retainer on brushes for accurate resistance readings.

Note: Use the values in Section 1, Specifications, as a reference for rotor resistance readings. Take readings at room temperature or about 21°C (70°F). Rotor resistance will vary directly with increase in temperature.

To check whether the rotor is shorted to ground, touch one ohmmeter lead to either collector ring and the other lead to the rotor poles or shaft. The meter should register no continuity.

Repair or replace the rotor if the previous tests detect any faults.

7.4 Stator

The stator consists of a series of coils of wire laid in a laminated steel frame. The stator leads supply voltage to the AC load and exciter regulator. See Figure 7-7 for coil lead description.

Stator Leads	Description
1-2	Output coil
3-4	Output coil
33-44	Control wires from 3 and 4
55-33	Voltage regulator power source
B1-B2	Controller power source

Figure 7-7 Stator Coil Lead Description

Before testing the stator, inspect it for heat discoloration and visible damage to the exposed coil windings and varnished areas of the frame laminations. Be sure the stator is securely fastened in the stator housing.

The stator produces electrical output (AC) as the magnetized main field rotates within the stator windings. Test the condition of the stator according to the following procedure.

Leads 1, 2, 3, and 4 are the generator output leads. Leads 33, 44, and 55 are the voltage regulator supply and sensing leads. The output of leads B1 and B2 is the control voltage for the controller.

Stator Test Procedure

1. Place the generator start/stop switch in the STOP position.

2. Disconnect the generator set engine starting battery, negative (-) lead first.

3. Check the generator output lead connections. See Section 10, Wiring Diagrams and Voltage Reconnection.

4. Disconnect all of the stator leads to isolate the windings. To check the stator continuity, set the ohmmeter on the R x 1 scale. Check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 7-8. Perform the stator tests on all the stator windings.

   Note: When taking an ohmmeter reading using lead 55, make the connection prior to the in-line fuse.

5. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads 1 and 2, 3 and 4, 55 and 66, and B1 and B2. See Section 1, Specifications, for the stator resistance values.

6. Perform a megohmmeter test on the stator as described in step 8.

   Note: Consider the stator functional if the resistance reading (continuity) is low and there is no evidence of shorted windings (heat discoloration).

   Note: The stator resistance varies directly with increased temperature.

7. If the stator readings vary considerably during the previous checks, repair or replace the stator.

8. Check the stator for a grounded condition using a megohmmeter. Apply 500 volts DC to any stator lead from each winding and the stator frame. Follow the instructions of the megohmmeter manufacturer when performing this test. Repeat the test on the other leads until all the stator windings have been tested. A reading of approximately 3–5 megohms and higher indicates the stator is functional. A reading of less than approximately 3–5 megohms indicates deterioration of the winding insulation and possible current flow to ground. Replace the stator.

Between Leads	Continuity
1 and 2	Yes
3 and 4	Yes
55 and 66	Yes
B1 and B2	Yes
1 and 3, 4, 33, 44, 55	No
1 and 55, B1 and B2	No
4 and B1 and B2	No
55 and B1 and B2	No
Any stator lead and ground	No

Figure 7-8 Stator Continuity

7.5 Brushes

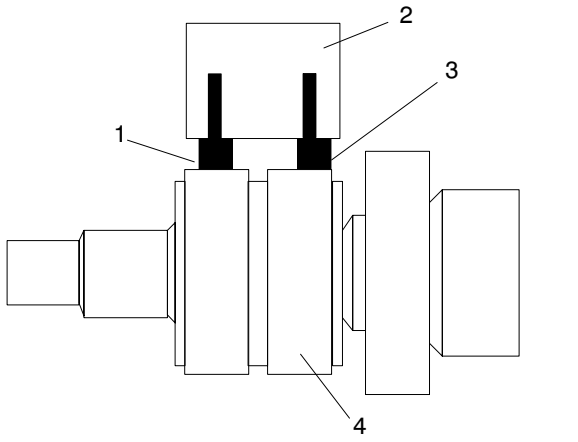
The brushes provide a current path from the voltage regulator to the collector rings. Because the brushes carry a low current, inspect them every 3000 hours. Abrasive dust on the collector rings could, however, shorten the life of the brushes. Excessive arcing at the brushes could damage the voltage regulator. Weak springs, damaged collector rings, sticking brushes, a loose holder, or poor brush contact can cause arcing at the brushes.

The brushes must be free to move within the holder and be held in contact by the springs. When properly positioned, spring pressure on the brush surface will cause the brush to wear evenly. Brushes must ride 100% on the collector rings or arcing will occur and cause burned rings or failure of the voltage regulator. Figure 7-9 shows the correct positioning of the brushes. Add or remove spacers as necessary to center brushes on collector rings.

Replace brushes if they show excessive or uneven wear.

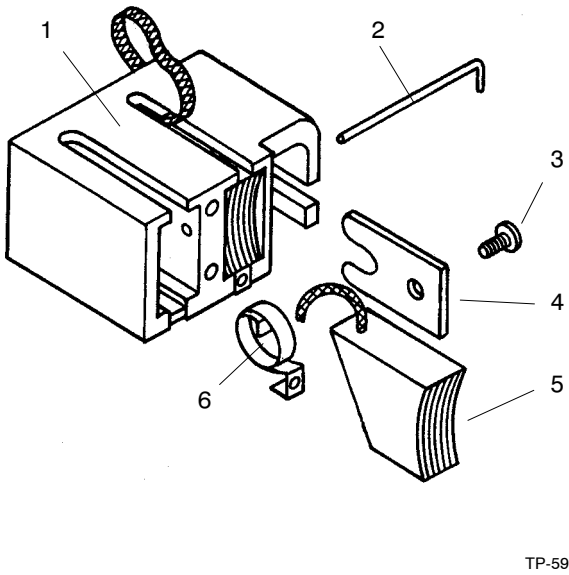
Use a retainer wire (such as a paper clip) to contain the brushes during disassembly and reassembly. Push the brushes into the brush holder until the retainer wire can be inserted into the brush keeping hole.

Replace brushes when they are worn to half of their original size.



1. Correct position
2. Brush holder
3. Incorrect position
4. Generator collector rings

Figure 7-9 Brush Positioning



1. Brush holder
2. Retainer (paper clip)
3. Mounting screw
4. Alignment shim(s)
5. Brush
6. Spring

Figure 7-10 Brush Holder

Notes

8.1 Engine/Generator Components

See Figure 8-1 through Figure 8-3 for engine/generator component testing. With the generator set battery connected, check the wiring harness and the engine/generator components listed in the following tables. Check each component using a multimeter to verify that the switches function and that voltage is present at each component.

Component	Voltmeter Connections	Procedure	Results
Hourmeter and wiring	Connect the red test lead to the hourmeter positive (+) terminal. Connect the black test lead to the hourmeter negative (-) terminal.	Set the voltmeter to 12 volts DC or greater. Start the generator set.	A 12 volt DC reading indicates the wiring harness is functional.
	None (see Procedure)	Disconnect the hourmeter leads and apply 12 volts DC to the hourmeter. The hourmeter is polarity sensitive.	If functional, hourmeter operates.
Stator auxiliary winding B1 and B2	Connect the AC voltmeter leads to the B1 and B2 windings at connector P11. Stop the generator set.	Set the voltmeter setting 20 volts AC or greater. Crank the generator set and allow the set to reach its rated speed.	A reading of 12–15 volts AC indicates a functional B1/B2 winding.

Figure 8-1 Engine/Generator Component Testing, Relay Controller

⚠ WARNING

Hazardous voltage.
Backfeed to the utility system can cause property damage, severe injury, or death.

If the generator set is used for standby power, install an automatic transfer switch to prevent inadvertent interconnection of standby and normal sources of supply.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove wristwatch, rings, and jewelry before servicing the equipment.

To further check the generator set components, disconnect the battery and remove the wiring harness plugs from the controller circuit board. Use an ohmmeter to check the continuity of the components and to isolate inoperative components. Refer to Figure 8-2 and Figure 8-3.

Note: Before performing ohmmeter checks, disconnect the generator set battery to prevent damage to the ohmmeter.

Component	Ohmmeter Connections	Procedure	Results
Start/stop switch	Connect the ohmmeter to the P2-6 and P2-4 leads.	Place the ohmmeter on the R x 1000 scale. Place the rocker switch in the START position.	If the switch is functional, zero ohms continuity. Any resistance other than zero or very low ohms, replace the switch.
	Connect the ohmmeter to the P2-6 and P2-5 leads.	Place the ohmmeter on the R x 1000 scale. Place the rocker switch in the STOP position.	If the switch is functional, zero ohms continuity. Any resistance other than zero or very low ohms, replace the switch.
K20 relay coil and wiring	Connect the ohmmeter to the P1-4 and P1-9 leads.	Place the ohmmeter on the R x 1 scale.	If functional, 85 ohms. Low resistance, shorted C relay coil and/or wiring. High resistance, open C relay and/or wiring.
Starter solenoid (S relay)	Connect the ohmmeter to the P4-22 lead and the battery positive (+) cable. **Note:** The J4 and P4 leads must be disconnected to perform this test.	Place the ohmmeter on the R x 1 scale.	If functional, approximately 0.5–0.6 ohms at 27°C (80°F).
Controller 10-amp circuit breaker and wiring	Connect the ohmmeter to the battery positive (+) cable and the P1-14 lead. **Note:** The J4 and P4 leads must be connected to perform this test.	Place the ohmmeter on the R x 1000 scale.	If functional, zero or very low ohms. No reading (infinity), open circuit or circuit breaker tripped.

Figure 8-2 Engine/Generator Component Testing, Relay Controller

Component	Ohmmeter Connections	Procedure	Results
Main field (rotor)	Disconnect the P10 and P11 connectors and connect the ohmmeter to P10-1 and P10-2 leads.	Place the ohmmeter on the R x 1 scale.	If functional, see Section 1, Specifications. Low resistance, rotor windings shorted. High resistance, rotor windings open.
B1/B2 stator windings	Connect the ohmmeter to the P11-1 and P11-2 leads. **Note**: Disconnect P11 and J11 to perform this test.	Place the ohmmeter on the R x 1 scale.	If functional, see Section 1, Specifications. Low resistance, B1/B2 windings shorted. High resistance, B1/B2 windings open.
P1 ground connection	Connect the ohmmeter to the P1-9 and ground.	Place the ohmmeter on the R x 1 scale.	If functional, zero ohms (continuity). Any other reading indicates a poor ground connection.
Low oil pressure (LOP) safety shutdown switch	Connect the ohmmeter to the P13-1 and engine block (ground).	Place the ohmmeter on the R x 1000 scale. This test is not conclusive until the temperature shutdown switches are checked.	If functional, zero ohms (continuity). Then, disconnect LOP switch lead and isolate terminal. Meter reading should show an open circuit.
High exhaust temperature (HET), low coolant (LCS) safety shutdown switches	Connect the ohmmeter to the P1-15 and engine block (ground). **Note**: Remove and isolate the LOP switch lead.	Place the ohmmeter on the R x 1000 scale.	If functional, open circuit. Any continuity suggests an inoperative temperature switch(es). Disconnect individual leads to inoperative switch.

Figure 8-3 Engine/Generator Component Testing, Relay Controller

8.2 Remote Panels (Optional)

Kohler Co. offers three remote panels for connection to the generator set:

- A panel with a start/stop switch
- A panel with a start/stop switch and two gauges (engine oil pressure and water temperature)
- A panel with a start/stop switch and four gauges (DC voltmeter, engine oil pressure, water temperature, and hourmeter)

If difficulty with the remote operation occurs, test the switch, gauges, and gauge senders using the following procedures. See Section 10.6, 10.7, or 10.8 to identify the location for the appropriate panel.

Troubleshooting Remote Start Panels

Generally, if the sender changes its resistance values as its respective pressure/temperature changes, it is working correctly. An inoperative sender will either be open or shorted. Refer to Figure 8-4 and Figure 8-5 for resistance values.

2-Meter and 4-Meter Panels Temperature	
60°C (140°F)	134 ± 10 ohms
90°C (194°F)	51.5 ± 4 ohms
100°C (212°F)	38 ± 3 ohms

Figure 8-4 Water Temperature Sender Resistance

2-Meter and 4-Meter Panels Pressure	
0 kPa (0 psi)	10 ohms
345 kPa (50 psi)	80 ohms
690 kPa (100 psi)	135 ohms

Figure 8-5 Oil Pressure Sender Resistance

Refer to Figure 8-6 for troubleshooting information on the remote start panels.

Component	Ohmmeter Connections	Procedure	Results
Remote start/stop switch	Remote switch: yellow/red wire terminal and black wire terminal.	Place the ohmmeter on the R x 1 scale. Press the rocker switch to the START position.	Continuity, the switch is functional.
	Remote switch: grey/black wire terminal and black wire terminal.	Place the ohmmeter on the R x 1 scale. Press the rocker switch to the STOP position.	Continuity, the switch is functional.
Generator set ON light, gauge lights, DC voltmeter, and hourmeter	Connect the red test lead to P3-4 and black test lead to P3-1.	If 12 volts DC is present and the component does not function after the J3 is connected to the controller P3, replace the component. Place the controller rocker switch to the START position. Stop the generator set when the test is complete.	Voltmeter setting 12 volts or greater. Generator set does not need to be running, just cranking for this test. **Note**: If the hourmeter is not illuminated, test by connecting it to a 12-volt battery. **Note**: The hourmeter is polarity sensitive.
Water temperature gauge	Connect the red test lead to P3-4 (socket side) and black test lead to P3-2 (socket side).	Start the generator set for the test. If 0.5–12 volts DC is present and the gauge does not function after the J3 is connected to controller, replace the gauge.	Voltmeter setting 12 volts or greater.
Oil pressure gauge	Connect the red test lead to P3-4 (socket side) and black test lead to P3-3 (socket side).	Start the generator set for the test. If 0.5–12 volts DC is present and the gauge does not function after the J3 is connected to the controller, replace the gauge.	Voltmeter setting 12 volts or greater.
Note: Check continuity of gauge wiring and extension harness before replacing components.			

Figure 8-6 Remote Start Panels Troubleshooting

9.1 Disassembly

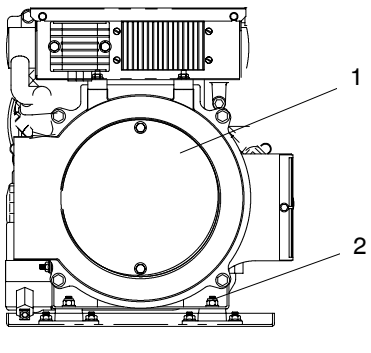
Disconnect the external connections—battery cables at the battery (negative (–) lead first), AC-output leads in the controller, remote start panel at the controller P3 connector and the fuel line at the fuel pump filter inlet. Observe all of the safety precautions listed during the disassembly/reassembly procedures.

Disassembly Procedure

1. Place the start/stop switch in the STOP position.
2. Disconnect the generator set engine starting battery, the negative (–) lead first.
3. Remove the controller cover.
4. Disconnect the P4 (22-pin) connector from J4.
5. Disconnect the controller ground strap (generator side).

   Note: It is possible to connect the output leads in various positions for different voltage configurations. Mark the leads for correct reconnection.

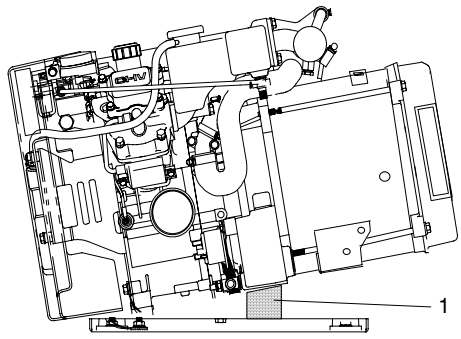
6. Disconnect the generator output leads 1, 2, 3, and 4 from the circuit breaker and the neutral stud (L0).
7. Disconnect the P11 (FP and FN) and P10 (F1 and F2) connectors.
8. Remove the fuel inlet hose.
9. Lift the controller from the rubber mounts while guiding the leads through the bottom opening of the controller box.
10. Remove the fuel pump and line from the generator.
11. Remove the alternator coverplate. See Figure 9-1.



1. Alternator end cover
2. Vibromount nuts

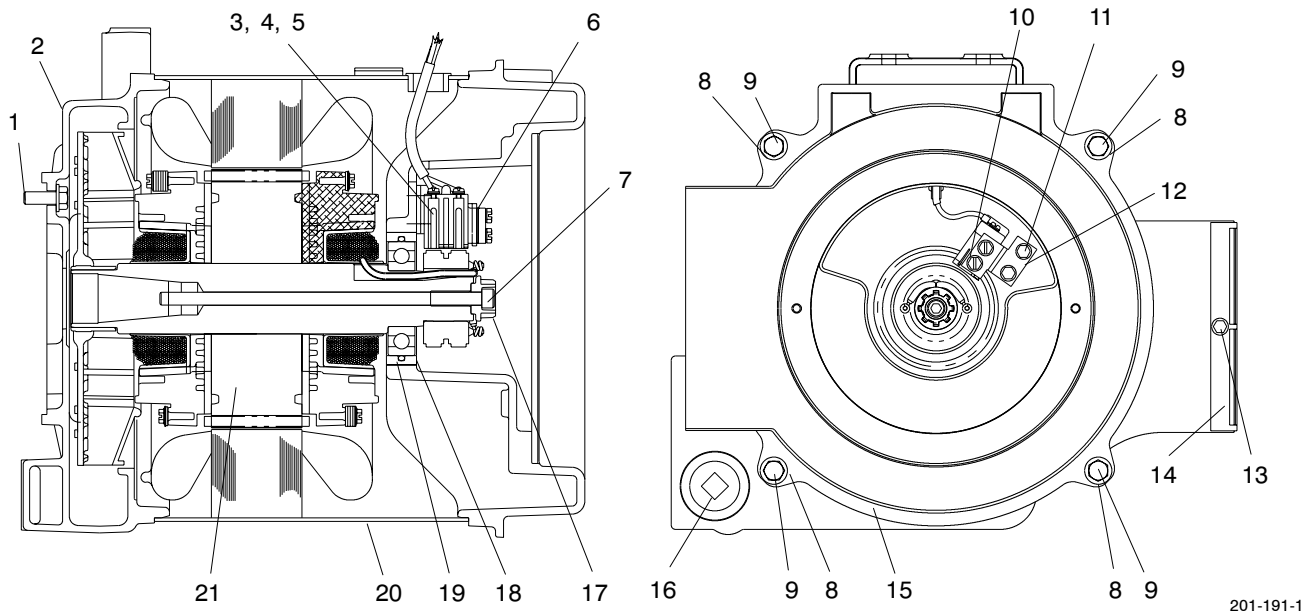
Figure 9-1 Alternator End Cover

12. Push the brushes into the holder. Secure the brushes into position by sliding a retainer into the brush keeping holes. Refer to Section 7.5.
13. Remove the brush holder and carefully pull the leads out of the stator housing. See Figure 9-3.
14. Remove the generator side vibromount nuts. See Figure 9-1.
15. Tilt the generator set up and brace it with a block of wood. Figure 9-2.



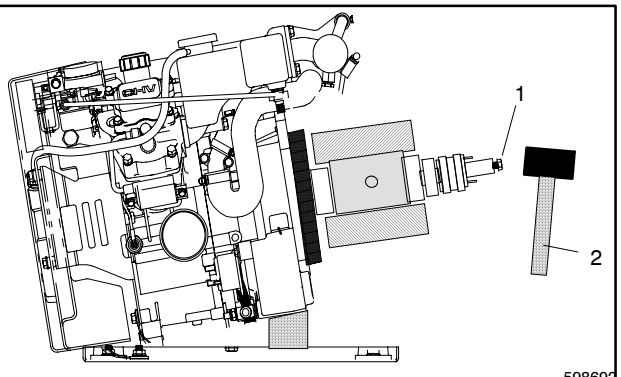
1. Block of wood

Figure 9-2 Raising the Generator, Typical



1. Generator adapter plate bolt, quantity 4
2. Generator adapter
3. Spring
4. Brush holder
5. Brush, quantity 2
6. Brush holder shim
7. Rotor bolt
8. Hardened washer
9. Generator overbolt, quantity 4
10. Retainer wire
11. Brush assembly mounting screws, quantity 2
12. Bracket, brush holder
13. Fan guard bolts, quantity 2
14. Fan guard
15. End bracket
16. Pipe plug
17. End drive fitting
18. End bracket bearing
19. O-ring
20. Stator assembly
21. Rotor assembly

Figure 9-3 Alternator Assembly Components



1. Rotor bolt
2. Hammer

Figure 9-4 Removing the Rotor

16. Remove the end bracket overbolts. See Figure 9-3. Use a rubber mallet to separate the end bracket from the stator housing.

17. Carefully remove the stator assembly from the generator adaptor plate.

18. Loosen the rotor bolt two turns.

19. Strike the bolt with a hammer until the rotor is freed from the engine tapered drive shaft. Do not damage through bolt threads or bolt head. See Figure 9-4.

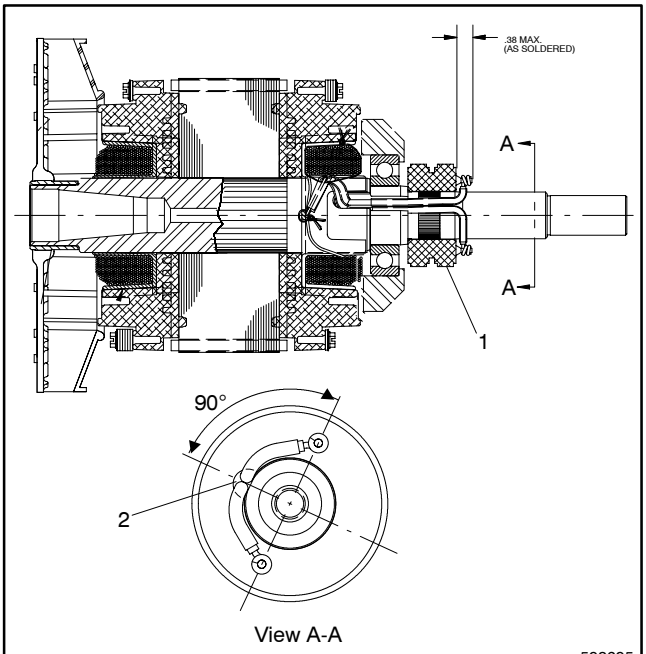
9.2 Collector Ring and Bearing Replacement

1. Unsolder the collector ring leads from the collector ring terminals.
2. Remove the collector rings with a 3-jaw puller.
3. Remove the bearing with a 3-jaw puller.
4. Press the new bearing onto the rotor shaft.
5. Align the collector ring keyway with the keyway on the rotor shaft. See Figure 9-6.
6. Press the new collector rings onto the rotor shaft.

   Note: The new collector rings must be turned down to a finish of 32 microinches using a lathe and commutator stones. Turn down the collector rings on the rotor shaft.

Min. diameter mm (in.)	57.15 (2.250)
Max. finish	32 microinches
Max. eccentricity mm (in.)	0.08 (0.003)
Max. out-of-round mm (in.)	0.01 (0.0002)

Figure 9-5 Collector Ring Dimensions



1. Collector ring leads
2. Keyways

Figure 9-6 Rotor Assembly

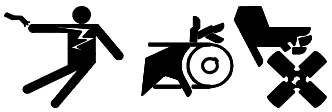
7. Solder the leads onto the collector ring terminals. The connection is not to exceed 9.65 mm (0.38 in.) beyond the collector rings. See Figure 9-6.
8. Test to ensure continuity at the collector rings.

9.3 Reassembly

1. Apply antiseize compound to the tapered shaft of the engine.
2. Align the rotor onto the engine shaft and secure with the end drive fitting and rotor bolt. Torque the rotor to 23.1 Nm (204 in. lbs.).
3. Carefully slide the stator assembly over the rotor.
4. Replace the end bracket O-ring.
5. Install the end bracket and torque the overbolts to 13.6 Nm (120 in. lbs).
6. Feed the brush leads inside the stator housing up through the opening. Secure the brush holder using the original screws.
7. Remove the brush retainer and check the brush alignment. See Section 7.5.
8. Install the coverplate and torque the coverplate bolts to 6.8 Nm (60 in. lbs.).
9. Install the fuel line and fuel pump.
10. Guide the leads from the stator through the bottom opening of the controller. Secure the controller.
11. Reconnect the leads from the stator to the controller using the reverse procedure of that listed in Section 9.1. Refer to Section 10, Wiring Diagrams and Voltage Reconnection.
12. Connect the generator set starting battery, the positive (+) lead first.
13. Test the generator operation.

Notes

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

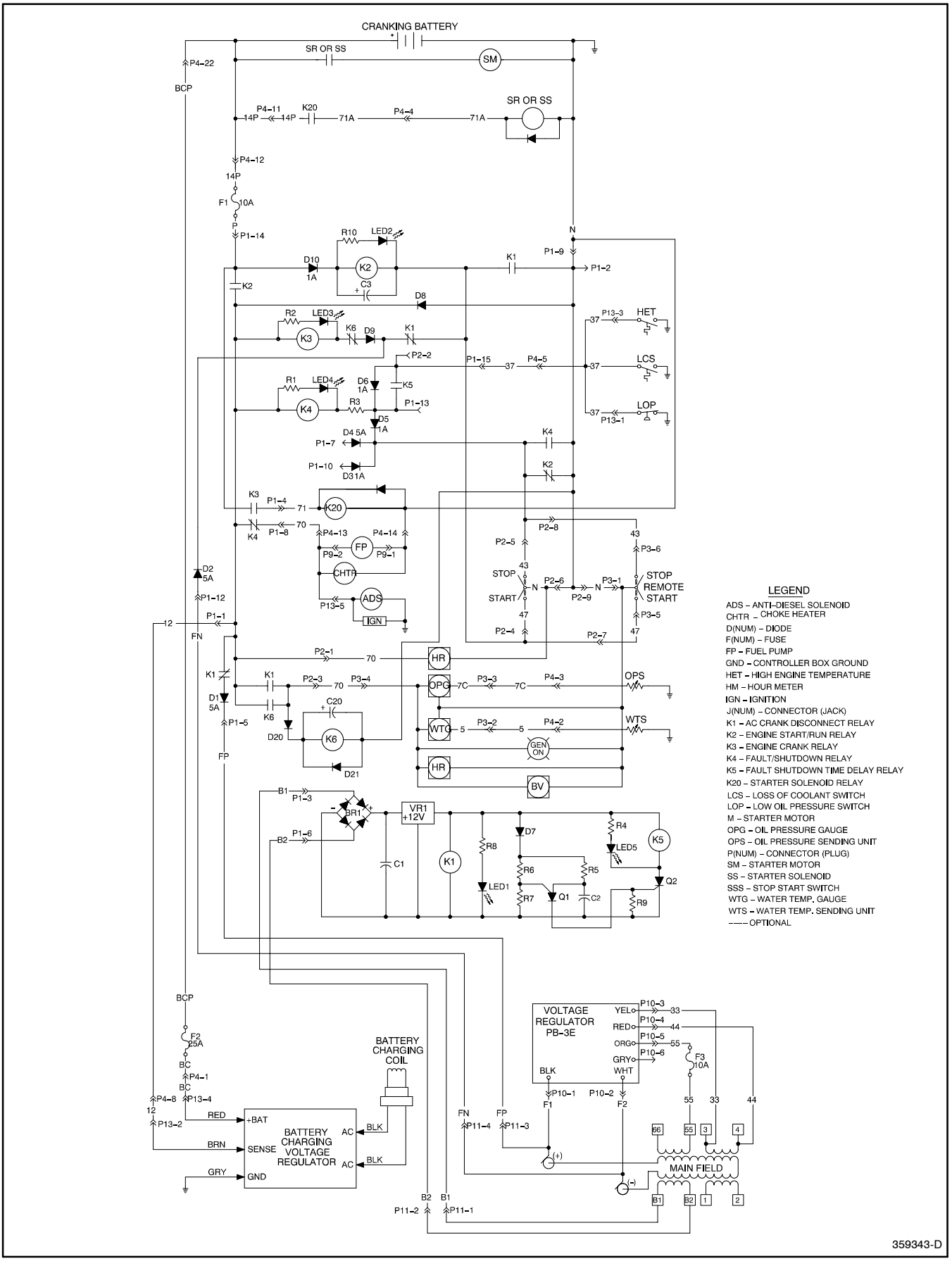
⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

10.1 Schematic Wiring Diagram



LEGEND

ADS – ANTI–DIESEL SOLENOID
CHTR – CHOKE HEATER
D(NUM) – DIODE
F(NUM) – FUSE
FP – FUEL PUMP
GND – CONTROLLER BOX GROUND
HET – HIGH ENGINE TEMPERATURE
HM – HOUR METER
IGN – IGNITION
J(NUM) – CONNECTOR (JACK)
K1 – AC CRANK DISCONNECT RELAY
K2 – ENGINE START/RUN RELAY
K3 – ENGINE CRANK RELAY
K4 – FAULT/SHUTDOWN RELAY
K5 – FAULT SHUTDOWN TIME DELAY RELAY
K20 – STARTER SOLENOID RELAY
LCS – LOSS OF COOLANT SWITCH
LOP – LOW OIL PRESSURE SWITCH
M – STARTER MOTOR
OPG – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SENDING UNIT
P(NUM) – CONNECTOR (PLUG)
SM – STARTER MOTOR
SS – STARTER SOLENOID
SSS – STOP START SWITCH
WTG – WATER TEMP. GAUGE
WTS – WATER TEMP. SENDING UNIT
–––– OPTIONAL

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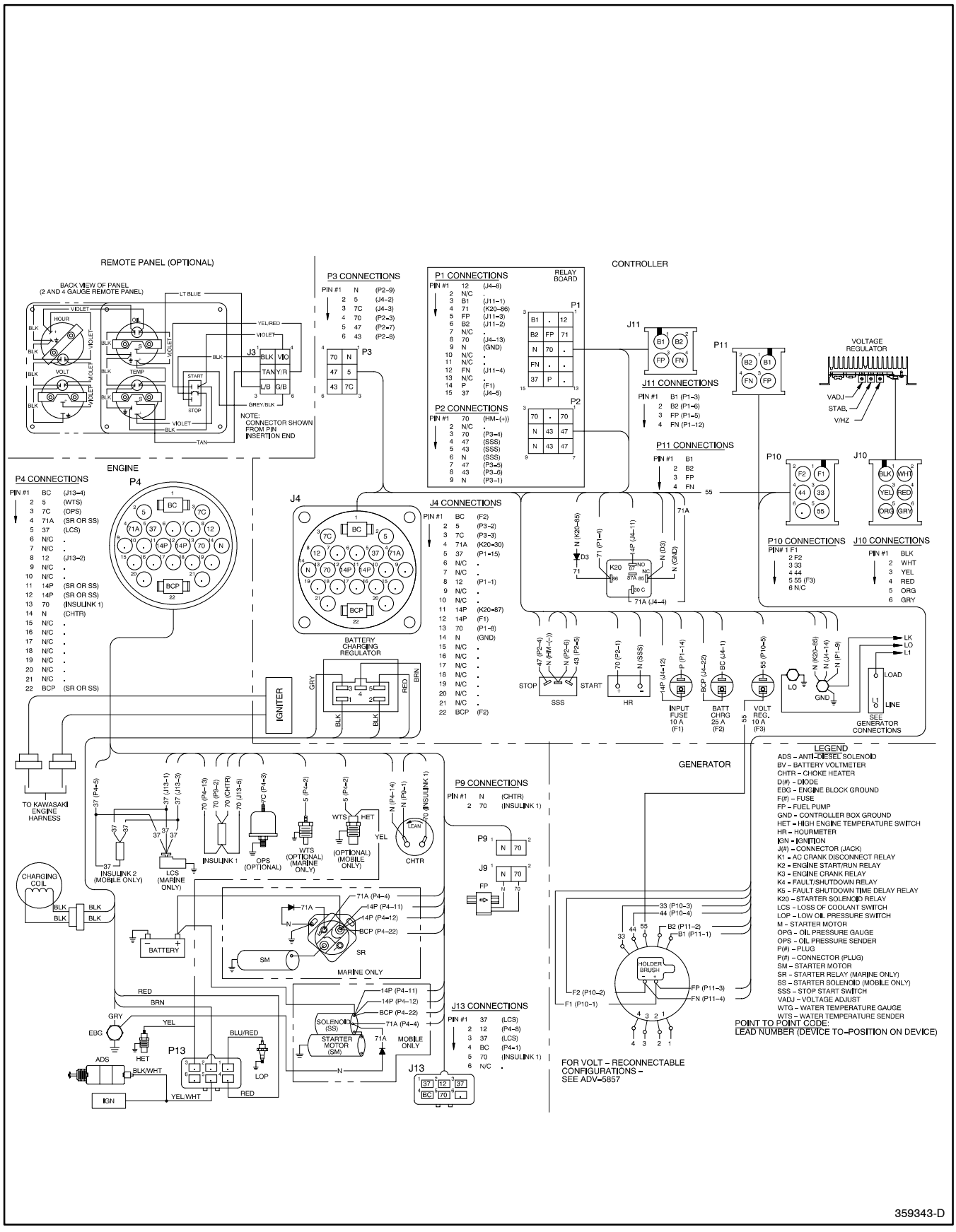
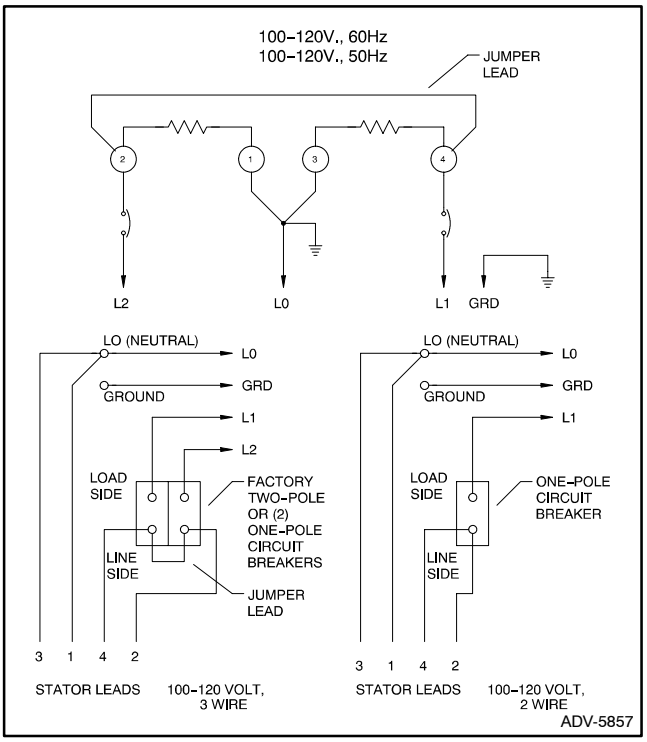
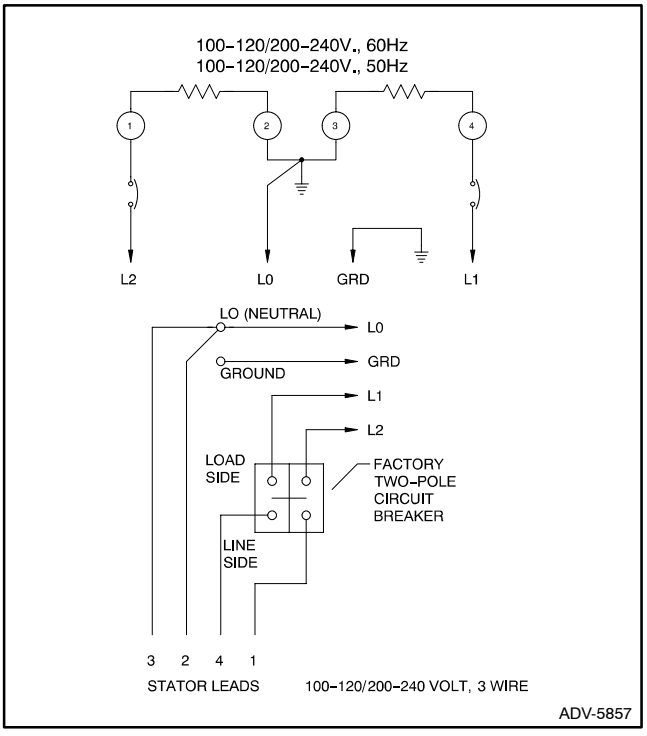
10.2 Point-to-Point Wiring Diagram



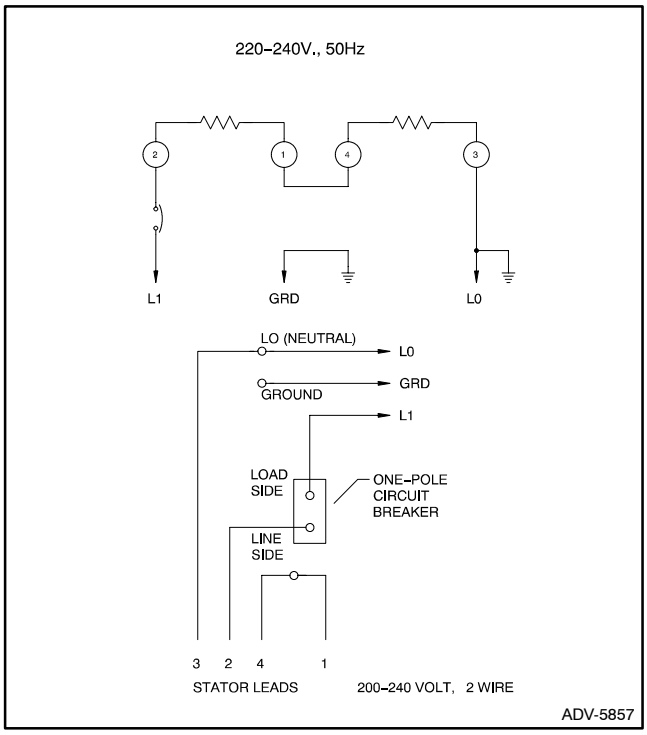
10.3 Reconnection Diagram 100–120 V, 60 & 50 Hz



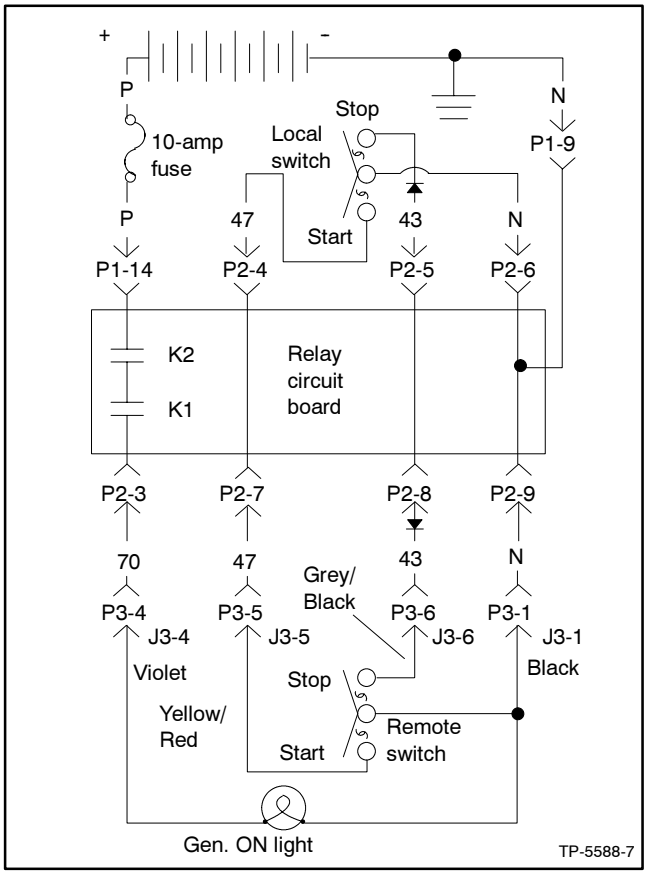
10.4 Reconnection Diagram 100–120/200–240 V, 60 & 50 Hz



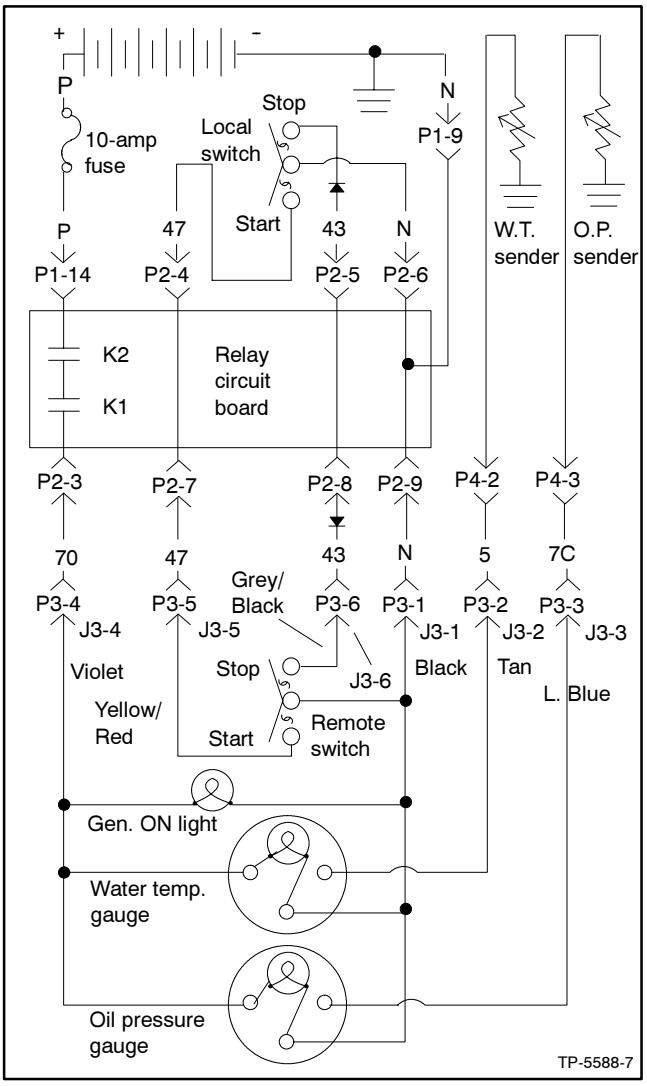
10.5 Reconnection Diagram 220–240 V, 50 Hz



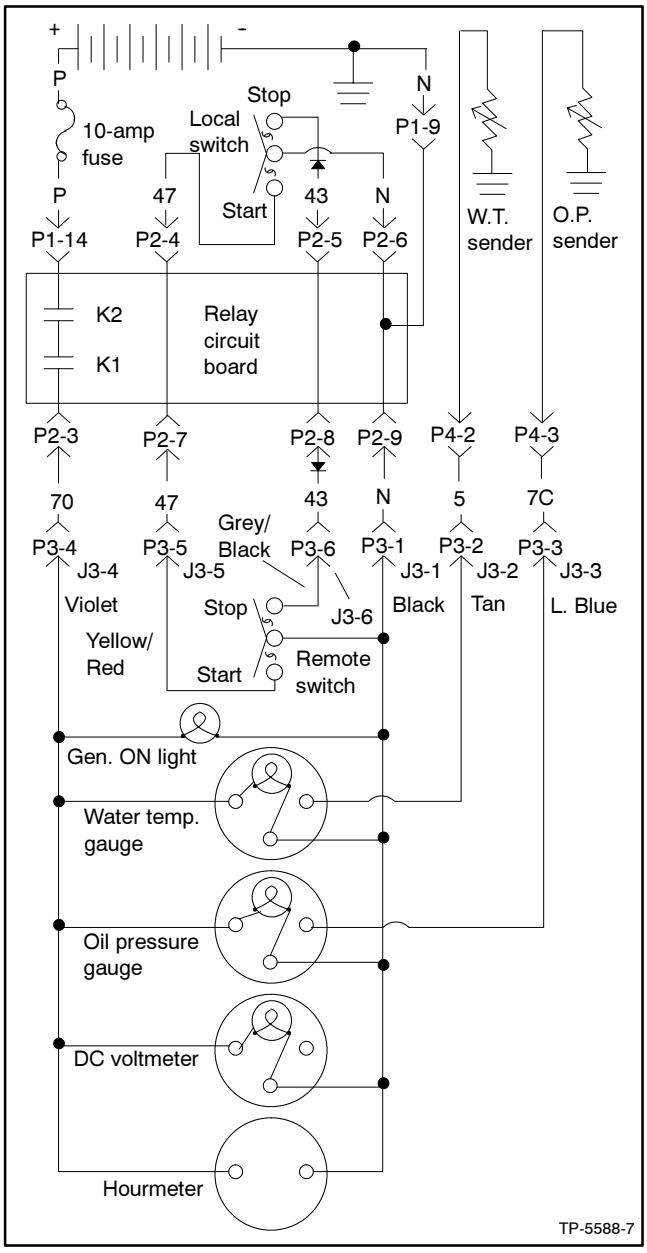
10.6 Remote Start Panel



10.7 Remote Start and Two-Meter Panel



10.8 Remote Start and Four-Meter Panel



Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audio/visual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
cmm	cubic meters per minute
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
COM	communications (port)
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example *(exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
gnd.	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin

kA	kiloampere
KB	kilobyte (2^{10} bytes)
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
O/C	overcrank
OD	outside diameter
OEM	original equipment manufacturer
O/F	overfrequency
opt.	option, optional
O/S	oversize, overspeed
OSHA	Occupational Safety and Health Administration
O/V	overvoltage
oz.	ounce
p., pp.	page, pages
PA	packed accessory
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph.	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
U/F	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
U/S	undersize, underspeed
UV	ultraviolet
U/V	undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See General Torque Specifications and other torque specifications in the service literature.

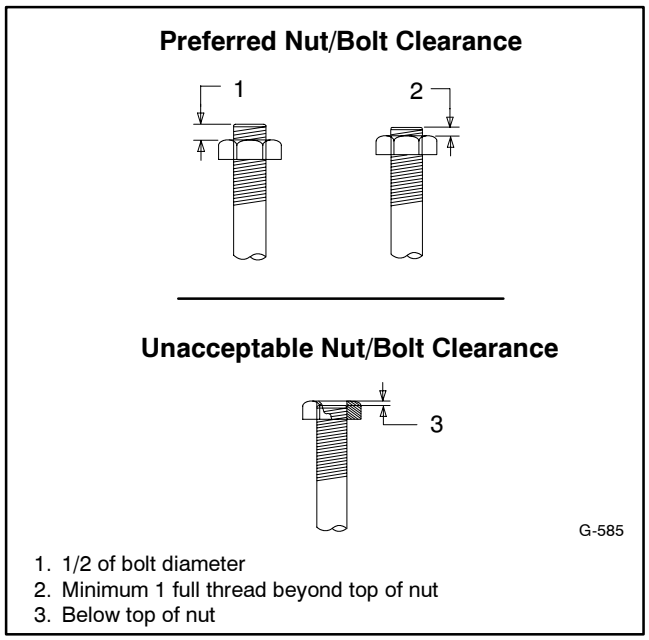


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See the diagram below.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to the diagram below, which depicts the preceding hardware configuration possibilities.

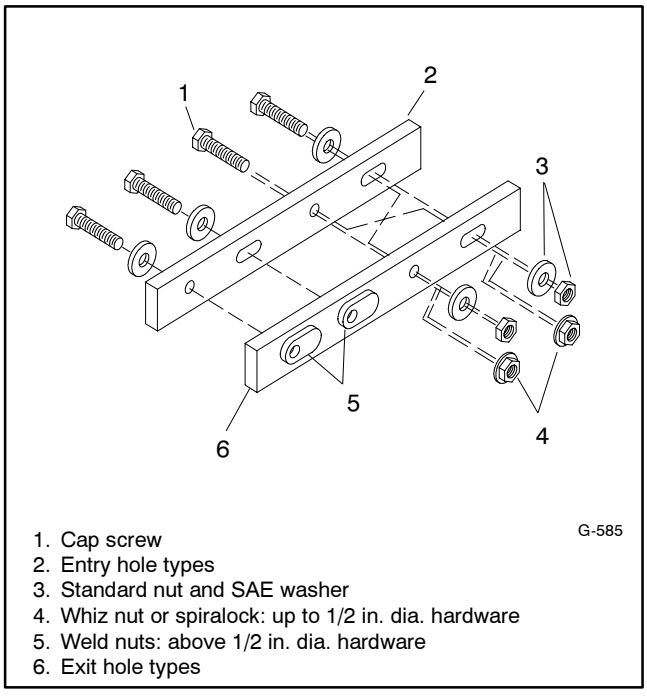


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

Use the following torque specifications when service literature instructions give no specific torque values. The charts list values for new plated, zinc phosphate, or oiled threads. Increase values by 15% for nonplated threads. All torque values are +0%/–10%.

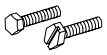
American Standard Fasteners Torque Specifications

Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum
		Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	in. lbs. (Nm)	16 (1.8)	20 (2.3)	—	16 (1.8)
10-24	in. lbs. (Nm)	26 (2.9)	32 (3.6)	—	26 (2.9)
10-32	in. lbs. (Nm)	26 (2.9)	32 (3.6)	—	26 (2.9)
1/4-20	in. lbs. (Nm)	60 (6.8)	96 (10.8)	132 (14.9)	60 (6.8)
1/4-28	in. lbs. (Nm)	72 (8.1)	108 (12.2)	144 (16.3)	72 (8.1)
5/16-18	in. lbs. (Nm)	120 (13.6)	192 (21.7)	264 (29.8)	120 (13.6)
5/16-24	in. lbs. (Nm)	132 (14.9)	204 (23.1)	288 (32.5)	132 (14.9)
3/8-16	ft. lbs. (Nm)	18 (24)	28 (38)	39 (53)	18 (24)
3/8-24	ft. lbs. (Nm)	20 (27)	31 (42)	44 (60)	20 (27)
7/16-14	ft. lbs. (Nm)	29 (39)	44 (60)	63 (85)	—
7/16-20	ft. lbs. (Nm)	32 (43)	50 (68)	70 (95)	—
1/2-13	ft. lbs. (Nm)	44 (60)	68 (92)	96 (130)	—
1/2-20	ft. lbs. (Nm)	49 (66)	76 (103)	108 (146)	—
9/16-12	ft. lbs. (Nm)	60 (81)	98 (133)	138 (187)	—
9/16-18	ft. lbs. (Nm)	67 (91)	109 (148)	154 (209)	—
5/8-11	ft. lbs. (Nm)	83 (113)	135 (183)	191 (259)	—
5/8-18	ft. lbs. (Nm)	94 (128)	153 (208)	216 (293)	—
3/4-10	ft. lbs. (Nm)	147 (199)	240 (325)	338 (458)	—
3/4-16	ft. lbs. (Nm)	164 (222)	268 (363)	378 (513)	—
1-8	ft. lbs. (Nm)	191 (259)	532 (721)	818 (1109)	—
1-12	ft. lbs. (Nm)	209 (283)	582 (789)	895 (1214)	—

Metric Fasteners Torque Specifications, Measured in ft. lbs. (Nm)

Size (mm)	Assembled into Cast Iron or Steel			Assembled into Aluminum
	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	4 (5.6)	7 (9.9)	10 (14)	4 (5.6)
M8 x 1.25	10 (13.6)	18 (25)	26 (35)	10 (13.6)
M8 x 1.00	16 (21)	18 (25)	26 (35)	16 (21)
M10 x 1.50	20 (27)	35 (49)	50 (68)	20 (27)
M10 x 1.25	29 (39)	35 (49)	50 (68)	29 (39)
M12 x 1.75	35 (47)	61 (83)	86 (117)	—
M12 x 1.50	48 (65)	65 (88)	92 (125)	—
M14 x 2.00	55 (74)	97 (132)	136 (185)	—
M14 x 1.50	74 (100)	103 (140)	142 (192)	—
M16 x 2.00	85 (115)	148 (200)	210 (285)	—
M16 x 1.50	104 (141)	155 (210)	218 (295)	—
M18 x 2.50	114 (155)	203 (275)	288 (390)	—
M18 x 1.50	145 (196)	225 (305)	315 (425)	—

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

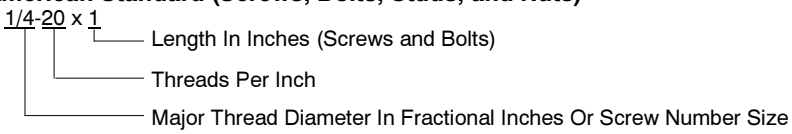
Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

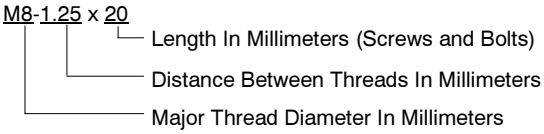
Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

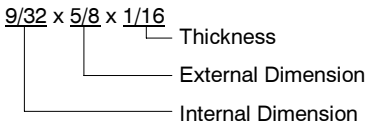
American Standard (Screws, Bolts, Studs, and Nuts)


1/4-20 x 1
Length In Inches (Screws and Bolts)
Threads Per Inch
Major Thread Diameter In Fractional Inches Or Screw Number Size

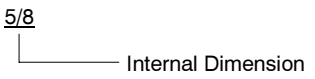
Metric (Screws, Bolts, Studs, and Nuts)


M8-1.25 x 20
Length In Millimeters (Screws and Bolts)
Distance Between Threads In Millimeters
Major Thread Diameter In Millimeters

Plain Washers



Lock Washers



Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14		Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Hex Head Bolts (partial thread)

Part No.	Dimensions
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10090-60	M10-1.50 x 90
M931-10100-60	M10-1.50 x 100
M931-12045-60	M12-1.75 x 45
M931-12050-60	M12-1.75 x 50
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12065-60	M12-1.75 x 65
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110
M931-16090-60	M16-2.00 x 90
M931-20065-60	M20-2.50 x 65
M931-20120-60	M20-2.50 x 120
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160

Hex Head Bolts (full thread)

Part No.	Dimensions
M933-04006-60	M4-0.70 x 6
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M933-12030-60	M12-1.75 x 30
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M933-16040-60	M16-2.00 x 40
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04020-20	M4-0.70 x 20
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12

Flat Head Machine Screws

M965A-05016-20	M5-0.80 x 16

Hex Nuts

Part No.	Dimensions	Type
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-05-50	M5-0.80	Standard
M982-05-80	M5-0.80	Elastic Stop
M6923-06-80	M6-1.00	Spiralock
M934-06-64	M6-1.00	Std. (green)
M982-06-80	M6-1.00	Elastic Stop
M6923-08-80	M8-1.25	Spiralock
M934-08-60	M8-1.25	Standard
M982-08-80	M8-1.25	Elastic Stop
M6923-10-80	M10-1.50	Spiralock
M982-10-80	M10-1.50	Elastic Stop
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-80	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M982-18-80	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-80	M22-2.50	Standard
M982-22-80	M22-2.50	Elastic Stop
M934-24-80	M24-3.00	Standard
M982-24-80	M24-3.00	Elastic Stop

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

* This metric hex bolt's hardness is grade 10.9.

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